OPTIMIZATION OF THE VELOCITY AZIMUTH DISPLAY (VAD) ALGORITHM'S ADAPTABLE PARAMETERS IN THE WSR-88D SYSTEM

THESIS

Daniel R. Farris, Capt, USAF

AFIT/GM/ENP/97M-05

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
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Wright-Patterson Air Force Base, Ohio

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THESIS

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Air Force Institute of Technology

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Daniel R. Farris, Capt, USAF

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Daniel R. Farris

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LIST OF ABBREVIATIONS AND SYMBOLS

AFB	Air Force Base
AGL	Above Ground Level
α	level of significance
AP	Anomalous Propagation
cm	centimeter
(FT)	VAD adaptable parameter - Number of fit tests
ft	feet
GB	gigabyte
Hgt	height
$\mathbf{H_0}$	null hypothesis
km	kilometers
kts	knots
LLWS	low-level wind shear
m	meters
mb	millibar
MHz	megahertz
nm	nautical miles
NCDC	National Climatic Data Center
NEXRAD	Next Generation Weather Radar (same as WSR-88D)
NOAA	National Oceanic and Atmospheric Administration
NPN	NOAA Profiler Network
(NPTS)	VAD adaptable parameter - Minimum number of samples
NSSL	National Severe Storms Laboratory
OSF	(NEXRAD) Operational Support Facility
PUP	Principal User Processor
pval	P-value calculated

(r)	correlation coefficient
(r^2)	coefficient of determination
RADS	Radar Algorithm Display System
RDA	Radar Data Acquisition
ρ	correlation coefficient (same as (r))
RMS	Root Mean Square error
RMSVD	Root Mean Square Vector Difference
RPG	Radar Product Generator
s	second
(TBZ/TEZ)	VAD adaptable parameter - Beginning and ending azimuth threshold
tcrit	Critical value of t-test
(THV)	VAD adaptable parameter - Threshold velocity
(THY)	VAD adaptable parameter - Threshold symmetry
tstar	Calculated value of t-test statistic
u	u-component
UTC	Universal Time Coordinated
v	v-component
VAD	Velocity Azimuth Display
(VAD)	VAD adaptable parameter - Range
VWP	Velocity Wind Profile
VTRPE	Variable Terrain Radio Parabolic Equation
w	w-component
WATADS	WSR-88D Algorithm Testing and Display System
WSR-88D	Weather Surveillance Radar-1988 Doppler (same as NEXRAD)

ABSTRACT

Meteorologists have encountered problems with the Velocity Azimuth Display (VAD) algorithm in the Weather Surveillance Radar - 1988 Doppler (WSR-88D) System. Under certain meteorological conditions, forecasters have observed differences between the radar's wind profiles and wind profiles from rawinsonde upper-air soundings, or wind profilers. One of the main causes of this problem is inversions in the atmosphere which cause the radar beam to subrefract or superrefract, causing the VAD winds to be inaccurately reported at a particular height.

This thesis used the WSR-88D Algorithm Testing and Display System (WATADS) to compare VAD winds from recorded Level II NEXRAD data at Vandenberg AFB, CA, with rawinsonde wind data and wind profiler data also recorded from Vandenberg. Approximately two weeks of data from each season in which low-level inversions in the atmosphere were present were used in this research. The adaptable parameters of the VAD algorithm were modified to determine if the VAD winds reported by the WSR-88D could be improved.

This research discovered that only modifying the VAD range adaptable parameter resulted in any significant improvement in the VAD winds. However, no single range value could be determined to work the best in all cases. The degree to which the range value optimizes the VAD winds is seasonally dependent. Overall, changing the VAD range value during low-level inversions might improve the VAD winds at one height, but will probably cause the VAD winds at another height to be unreliable.

OPTIMIZATION OF THE VELOCITY AZIMUTH DISPLAY (VAD) ALGORITHM'S ADAPTABLE PARAMETERS IN THE WSR-88D SYSTEM

1. Introduction[1]

a. Statement of the problem

Meteorologists have encountered problems with the Velocity Azimuth Display (VAD) algorithm in the Weather Surveillance Radar -1988 Doppler (WSR-88D) System. Under certain meteorological conditions, forecasters have observed differences between the radar's wind profiles and wind profiles from rawinsonde upper-air soundings and other sources of wind data. One discrepancy noted was high winds were displayed by the Velocity Wind Product (VWP) product produced by the VAD algorithm, but the sounding reported light winds. Another case was light winds or zero values displayed by the VWP product when the sounding reported high winds. Instances where VWP winds were 180^0 different from the sounding have also been reported by forecasters.

b. Importance of research

These problems must be resolved because errors in calculating the VAD wind data by the WSR-88D could introduce errors in other algorithms used by the radar. This problem not only affects weather forecasts produced by civilian meteorologists, but forecasts made by military weather personnel as well. Winds have a direct effect on military aircraft

[1] Note: For each chapter, the figures and tables mentioned in the text are given at the end of the chapter.

operations. Winds can cause damage to military aircraft in the air or on the ground. Aircrews briefed by the base weather station forecaster need an accurate depiction of the winds, especially during conditions of low-level wind shear (LLWS) or other turbulent conditions. Accurate wind forecasts are also needed for the routine take-off and landing of an aircraft. In addition, a true knowledge of the winds is especially needed for base resource protection. For example, accurate wind data is a critical input to the military weather computer program Toxic Corridor, which calculates the dispersion of hazardous chemicals into the air from incidents such as an accidental fuel spill. Inaccurate wind data could put the lives of military personnel in danger by not being evacuated from a hazardous area.

Another reason to address this problem is that errors in wind data will not allow the forecaster to get an accurate picture of the state of the atmosphere at a particular location, leading to possible erroneous weather forecasts. An accurate knowledge of the winds, especially in the boundary layer, could improve forecasts for severe weather since the development of severe storms is directly related to changes in low-level wind shear, temperature, and moisture (Stensrud, 1986).

c. *Background*

1) THE WSR-88D SYSTEM

The WSR-88D is the product of the Next Generation Weather Radar (NEXRAD) Program. There are approximately 145 operational systems in the United States which provide nearly complete radar coverage of the contiguous United States at an altitude of

about 10 000 feet. There are also about 13 radar systems that are deployed in the Caribbean, Alaska, Hawaii, and at U.S. military bases overseas (Crum and Alberty, 1993b).

The WSR-88D system has many advantages over the different types of conventional radar (the WSR-57, the WSR-74, and the FPS-77) it is replacing. The WSR-88D radar not only measures the received power from the amplitude of the received signal (reflectivity), but also provides information about the phase of the received signal (velocity). A conventional radar does not provide any information about the phase of the signal. Compared to the weaker conventional radar, the WSR-88D system also has enhanced capabilities, improved resolution, improved sensitivity, and automatic volume scanning. The WSR-88D system is periodically modified and enhanced, including the meteorological algorithms, as requirements change, advances in technology are made, or problems are discovered.

The WSR-88D "collects, processes, and displays high-resolution, and high accuracy of, reflectivity, mean radial velocity, and spectrum width data" (Crum and Alberty, 1993b). From these base products, computer algorithms create a number of meteorological and hydrological products that a meteorologist can use to produce a weather forecast. Many of the algorithms have adaptable parameters to optimize each radar according its geographical, climatological, and site-specific conditions. The algorithms can also be adjusted for varying operational requirements (e.g., civilian vs. military). Figure 1 shows the meteorological algorithms processing flow by the WSR-88D

system starting from the Radar Data Acquisition (RDA), through the Radar Product Generator (RPG), to the products displayed at the Principal User Processor (PUP).

There are approximately 11 500 adaptable parameters for each WSR-88D (Crum and Alberty, 1993b). There are three different classifications of the adaptable parameters: meteorological, engineering, or operational. The meteorological adaptable parameters consist of approximately 400 variables used to optimize the performance of the radar's algorithms. An example of this type of algorithm would be adjusting the shear criteria for the triggering of the mesocyclone algorithm. The 600 engineering adaptable parameters affect the radar's performance in meeting technical requirements. Examples of this type of algorithm would be defining clutter filters and establishing communication links. The approximately 10 500 operational adaptable parameters have a direct impact on the performance of the radar and indirectly affect the computed algorithms. Examples of this type of adaptable parameter would be the product generation priority and the product distribution control (Crum and Alberty, 1993b).

Level II data from the WSR-88D will be used in this research. Level II data is digital base data output produced by the radar's signal processor in polar format at the full spatial and temporal resolution of the WSR-88D. This data is collected by the computers located at the Radar Data Acquisition (RDA). Level II data contains reflectivity, mean radial velocity, spectrum width, and system status information (such as operational mode, date, time, and antenna position). The WSR-88D then uses the Level II data to process and calculate the meteorological and hydrological algorithms. Most importantly, Level II data

can be recorded on an 8 mm tape that can hold approximately 4.7 GB of data per tape. This tape can then be played back through the radar or other computer software at the same speed as the data was collected. Researchers use Level II data to develop enhanced meteorological algorithms for the WSR-88D, to refine the adaptable parameters of these meteorological algorithms according to climate and geographic location, and to develop and improve training modules for the WSR-88D.

2) THE WSR-88D VELOCITY AZIMUTH DISPLAY (VAD) ALGORITHM AND VELOCITY WIND PROFILE (VWP) PRODUCT

The VAD algorithm creates products used to estimate wind speed and direction. The VAD product can also be used to determine divergence, stretching, and shear deformation. However, the VAD product is only displayed when the radar is in clear-air mode. Therefore, the VAD winds created by the VAD algorithm are output to two important places – the Velocity Winds Profile product (VWP), and the Environmental Winds Table. The VWP product continues to be one of the WSR-88D's most widely used and accepted algorithm-derived products (Steadham and Lee, 1995). The VWP product displays the VAD wind data in all operational modes of the radar. The performance characteristics of the VAD algorithm, along with the VAD and VWP products, must be understood before trying to optimize the adaptable parameters of the VAD algorithm.

The VAD analysis is based on the assumption that the horizontal winds around the radar are uniform; there are no sharp gradients in the wind speed or direction around the radar. To determine the wind direction and speed with height, the WSR-88D scans

complete revolutions at constant elevation angles (Bluestein, 1992). The algorithm uses a single elevation angle at a constant range to determine the wind speed and direction for a specified height. The radial wind speed reaches a maximum downwind while moving away from the radar, and also reaches a maximum upwind while moving towards the radar. The wind calculated for a particular height is associated with a VAD at a given range. Equation (1) shows how the radar calculates the Doppler velocity (v_r) (Bluestein, 1992).

$$v_r = v_h \cos\beta \cos\alpha + (w + v_f) \sin\alpha \qquad (1)$$

where

v_h = Horizontal component of the radial Doppler velocity,

v_f = Terminal fall velocity of the scatterers,

α = Elevation angle,

w = Air vertical velocity, and

β = Azimuth measured in degrees counterclockwise from a reference direction (such as the x axis).

The WSR-88D radar calculates the VAD product for each particular height from the scattering of data points it finds from each elevation angle scan. These data points are then used to compute the wind speed and direction for each height. A maximum of 30 VAD products corresponding to 30 different heights may be obtained during each volume scan of the radar. The VAD product displays a graphical plot of mean radial velocity as a function of azimuth angle for a particular altitude. Once the data points are plotted, assuming all adaptable parameter thresholds are met, a sine wave is fit to the data using

the least squares fit methodology. The VAD wind is then computed from this sine wave. One advantage of the VAD analysis is it needs only a specified number of data points to plot the sine wave. It does not require 360 degrees of data. The amplitude of the sine wave is the estimated wind speed. The maximum amplitude in the strongest negative portion of the sine wave is the estimated wind direction. Figure 2 shows how a velocity-azimuth display works, and Figure 3 shows an actual VAD product display from a WSR-88D system.

Examining the sine wave in Figure 2, a forecaster can easily determine wind speed and direction, along with convergence and divergence. For instance, a negative (inbound) amplitude greater than the positive (outbound) amplitude with the same direction, is an indication of speed convergence. Speed divergence would be the opposite case. If the sine wave crosses the zero line once, left of the 180^0 mark, directional convergence is indicated. Directional divergence occurs if the sine wave crosses to the right of the 180^0 mark.

The VAD algorithm next calculates the Root Mean Square (RMS) error and symmetry. RMS error is the amount of scattering between the best fit sine wave and all of the data points. The RMS error expresses the reliability of the estimated wind speed and direction. A high RMS error indicates wind estimates are less likely to be accurate. However the VAD product should be manually examined to check if a single outlier data point is not responsible for the high RMS value. Symmetry is the difference in knots between the zero velocity line on the VAD grid and the median line of the sine wave

curve. For example, if the wind is a uniform 360 degrees around the radar, symmetry would be zero. If the symmetry value increases, the fitted sine wave is probably not representative of the actual winds. Symmetry is used to determine if convergence or divergence is occurring at the radar. However, the symmetry of the fitted sine wave curve is not plotted on the VAD product. If thresholds for the RMS error or symmetry are exceeded, the VAD algorithm will not output the wind data for that particular altitude to the VWP product. However, the operator can still view the sine wave curve plotted with the VAD product for that altitude to estimate the winds. One of the main uses of the VAD product is to check suspicious or missing wind data on the VWP product (Klazura and Imy, 1993).

Errors with the VAD algorithm usually occur whenever the homogeneous wind assumption is not valid. Discontinuities from frontal boundaries, wind shift lines, and outflows from thunderstorms are all examples of meteorological phenomena that can cause the wind field around the radar to be non-homogeneous. Incorrect conclusions can be drawn about the computed wind field if these nonlinearities are not accounted for (Caya and Zawadski, 1992). The VAD algorithm calculates the wind only if there are enough echoes to receive coherent Doppler velocity estimates.

The VWP product displayed by the WSR-88D depicts mean horizontal winds from radial velocity measurements on a time versus height chart, showing a forecaster a vertical profile of wind speed and direction. The winds are computed by the VAD algorithm for each height level. The VWP product can display up to 30 levels ranging from the surface

to 21 km at 5 to 10 minute intervals (Federal Meteorological Handbook No. 11, Part C, 1991). The product also shows the latest vertical wind profile, along with the 10 most recent profiles. A maximum of 30 altitudes can be displayed for each profile, with a minimum of 1000 ft between levels. Figure 4 shows an example of a VWP product from a WSR-88D system.

A major advantage of the VWP product is that it is updated every 5 to 10 minutes depending on which mode the radar is in, compared to an hourly update of winds displayed by a wind profiler, or wind data from a rawinsonde that is updated usually only every 12 hours. An operational advantage of the VWP product is it allows a forecaster to easily monitor backing or veering of the winds with time, indicating changes in temperature advection. This could be especially critical during severe weather conditions. Another benefit is the VWP product may be used in estimating cloud tops and bases, since most scatterers are prevalent in and near clouds. Climb winds, flight level winds, jet streams, boundary layers, and inversions can also be determined from the VWP product.

There are only a few reasons why a VWP product would not report any wind data. The RMS or symmetry thresholds have been exceeded, or there are too few data points for the VAD algorithm to construct a sine wave. Another limitation of the VWP product is that it is only a representation of the winds within approximately 20 nm of the radar. The representation of the winds by the VWP product could be inaccurate if the basic assumption that the winds are uniform around the radar is not valid.

In addition to the VWP product, the VAD winds are also sent to the Environmental Winds Table used in the velocity dealiasing algorithm. If the VAD winds are unreliable, a forecaster can manually update the winds from a rawinsonde sounding.

The VAD algorithm has seven adaptable parameters which are listed below:

Note: The system defaults are in parenthesis (Federal Meteorological Handbook No. 11, Part C, 1991).

(VAD) - VAD Range (30 km or 16.2 nm) - This algorithm uses this range along with the closest elevation angle to determine the winds at each altitude. Varying the VAD range threshold will affect the scales of motion that can be detected. A lower value will cause the radar to use higher tilts. Varying the range can be an effective way to eliminate ground contaminated return. At short ranges, ground clutter can completely saturate data. At long ranges, the resolution of the Doppler radar decreases.

(TBZ, TEZ) - Beginning and Ending Azimuth Thresholds (0^0-359^0, 0^0-359^0) - The VAD analysis uses only the data points obtained between the beginning and ending azimuth angles, thus 360^0 of data is not required to compute the VAD winds. This threshold could be used to decrease anomalous propagation (AP) or discontinuities in the boundary from the wind calculations. These two parameters allow the elimination of contaminated sectors.

(THV) - Threshold Velocity (5 m s^{-1} or 9.7 kts) - This threshold is the maximum root mean square (RMS) error allowed for wind estimates to be declared valid. Decreasing this threshold may cause the data to be incorrectly labeled as bad. There is a rapid loss of the potential number of wind values used by the algorithm. Increasing this threshold may result in a sine curve that does not accurately represent the wind field The number of potential wind values increases, which might include spurious data.

(THY) - Threshold Symmetry (7 m s^{-1} or 13.6 kts) - This threshold is the maximum allowed asymmetry of a least square fit sine curve to be declared valid. Decreasing this threshold may cause the data to be incorrectly labeled as bad. Increasing this threshold may result in unrealistic divergence values.

(FT) - Number of Fit Tests (2) - This threshold is the number of times the low velocity data point outliers are removed and a new VAD harmonic analysis is performed. The fit test eliminates the data points which are more than 1 RMS away from the least squares fit sine curve. Decreasing this threshold to a value of 1 would disable the removal of the low velocity data outliers. However, a second pass is usually necessary to remove ground

clutter biases from the wind estimates. Increasing this threshold to a value of 3 or higher, more data would be removed, including good data.

(NPTS) - Minimum Number of Samples (25) - This threshold is the minimum number of data points needed for a harmonic analysis. Decreasing this threshold would likely cause the resulting sine curve to inaccurately represent the true wind field.

These are the adaptable parameters which are the main focus of this thesis.

3) RAWINSONDES

Rawinsondes are the primary source for upper-air measurements of the atmosphere. Rawinsondes are balloon-borne instruments which conduct in situ measurements of temperature, moisture, pressure, winds, and height information. The balloons are tracked by radar or some other direction finding device. The accuracy of a rawinsonde varies from 1 m s^{-1} at lower altitudes to 10-20 m s^{-1} near the tropopause around a jet (Bluestein, 1992). The stronger the winds are aloft, the greater the accuracy is reduced.

Measurements are taken around the world usually twice daily at 0000 UTC and 1200 UTC. The rawinsonde provides measurements that are averaged over time during the course of the balloon's trajectory through layers in the troposphere 300-400 m thick and are assigned to the center of each layer. The height of the rawinsonde is calculated by the conversion of the pressure readings to corresponding altitudes by the hydrostatic equation. The error is usually 20 m at an altitude of 10 km and increases to 100 m at 30 km. (Golden et al., 1986). Any error in pressure measurement will directly affect the calculation of the altitude of the balloon. The pressure-altitude error is about 50 m at 10 km, increasing to 500 m at 30 km (Golden et al., 1986).

The wind speed and direction measurements from rawinsonde data in determining the synoptic scale geostrophic flow pattern are usually representative of the actual atmosphere. However, there are many possible sources of errors that can lead to wind data which is unrepresentative of the atmosphere. For example, many questions must be asked about the sounding data, such as: where and when was the sounding taken? Did

any local terrain or mesoscale disturbances influence the data? (Golden et al., 1986). Another possible source of error in rawinsonde data occurs when the balloon is far downstream from its launch point due to strong winds aloft. The radar beam tracking the balloon may be at a very low elevation angles, which can increase the errors due to the radar beam reflecting from terrain (Weber et al., 1990). This results in larger errors expected in the wind values reported at the greatest heights. Another possible error is sharp gradients in the winds have a tendency to be smoothed by the rawinsonde. This problem has resulted in underestimating the magnitude of the jet stream, at times up to 20% (Golden et al., 1986). Also, the rawinsonde balloon itself is susceptible to bad weather conditions. The balloon can be difficult to launch in strong winds, rain, snow, or sleet.

Finally, a major disadvantage of a rawinsonde balloon is the winds cannot be determined continuously in time. There usually must be a minimum of 45 minutes between balloon launches if the same frequency is used to transmit the data (Bluestein, 1992). It is possible to use separate frequencies for each balloon; however, this can be a costly procedure.

4) WIND PROFILERS

Wind profilers are similar to the WSR-88D radar in that they both can be used to almost continuously monitor the wind field. A wind profiler is a highly sensitive 404 MHz Doppler radar (74 cm wavelength) that scans vertically, measuring the horizontal wind speed and direction above a profiler location from near the surface to above the

tropopause. A vertical profile of the winds is produced every hour, allowing a forecaster to monitor the variation of the wind with height over time. There are currently 32 wind profilers located around the nation, mainly in the central United States, which make up the NOAA Profiler Network (NPN).[2]

Wind profilers use a fixed antenna that uses three separate radar beams to measure the u, v, and w components of the wind. To measure the horizontal wind components, two of the beams are tilted approximately 15^0 from zenith toward the east and north. The third beam is pointed upward to measure vertical motion (Weber et al., 1990). It is assumed that the wind field is homogeneous in the horizontal and vertical in the vicinity of the wind profiler. Figure 5 shows the tilting of the radar beams from a wind profiler. The phased array antenna would be located at the ground.

Wind profilers work by detecting fluctuations in atmospheric density, which is caused by the turbulent mixing of volumes of air with slightly differences in temperature and moisture. This results in fluctuations in the index of refraction, which is used as a tracer of the mean wind in clear air. A wind profiler is usually a long wavelength, low power, and highly sensitive clear-air radar, although the profiler can operate in cloudy conditions or during precipitation. These conditions usually do not cause any degradation of the wind profiler data unless the horizontal or vertical motions within the beams become non-uniform, such as during frontal passages or convective storms.

[2] From "NOAA Profiler Network." WWWeb, http://www-dd.fsl.noaa.gov/aboutnp.html (18 Sep 96).

The wind profilers operate continuously, alternating sample modes every 1 minute between low or high mode, and switch beam positions (eastward, northward, or vertical) every 2 minutes. The low mode scans the lower atmosphere from 500 m above ground-level (AGL) up to 9.25 km AGL. The high mode scans from 7.5 km AGL to 16.25 km AGL. Each mode samples winds at 36 different height levels, spaced every 250 m in the vertical. The graphical display of the wind profiler displays winds at each height sampled showing an hour average wind from the preceding hour of wind data. For example, wind data obtained between 1100-1200 UTC would be averaged and displayed as winds for 1200 UTC. Figure 6 shows an example of the wind profiler output from Vandenberg.[3]

The winds are not displayed by the profiler unless they have passed single-station quality control requirements, such as continuity checks and bird contamination checks. Therefore, the winds obtained from the wind profiler represent high quality data. In the overlapping region between the low and high sampling modes (7.5 km-9.25 km AGL), wind data from the high mode are displayed unless the data does not pass the quality checks, in which case the wind data from the low mode would be displayed, assuming it passed the quality checks.

The wind profiler has several advantages compared to a rawinsonde. The profiler produces an hourly averaged wind profile every hour, and it also measures the winds almost directly above its location. Also, the wind profiler is not as susceptible to bad weather conditions, and the accuracy of the wind profiler data is not reduced by high

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[3] From "NOAA Profiler Network." WWWeb, http://www-dd.fsl.noaa.gov/cgi-bin/testsend_gif.pl?Product=WINDS&Profiler=VBGCI&method=none (5 Jan 97).

winds aloft like the rawinsonde data. Some disadvantages of the wind profiler are it provides no wind measurements in the first 500 m (1600 ft) of the atmosphere, and also cannot measure temperature and moisture. The profiler is also sensitive to nearby radio interference. Also, errors can result if the gradient of the index of refraction is not large enough to be detected by the wind profiler (Bluestein, 1992). The capabilities of the profiler are not as strong during the winter since scattering in the atmosphere is usually relatively weak in relatively cold, dry conditions (Martner et al., 1993).

5) WSR-88D ALGORITHM TESTING AND DISPLAY SYSTEM (WATADS)

WATADS will be used to optimize the VAD algorithm's adaptable parameter settings for specific weather phenomena. WATADS is a software package developed by the National Severe Storms Laboratory (NSSL) for their internal use to test various WSR-88D algorithms, and special NSSL created enhanced algorithms. WATADS uses recorded Level II data from a WSR-88D system. This gives the user the capability to test many different types of concepts using WSR-88D data, such as conducting algorithm adaptable parameter optimization studies, studying algorithm performance, comparing of baseline and enhanced algorithm performance, creating case studies, and developing training scenarios (WSR-88D, 1995). Using WATADS, the user can easily change an algorithm's adaptable parameters to view the effects the changes would have on the WSR-88D output.

WATADS displays the WSR-88D base data, and executes and displays the algorithm output (WSR-88D, 1995). The display software is a version of the NSSL developed

Radar Algorithm Display System (RADS) (WSR-88D, 1995). With WATADS, the user can examine radar data and algorithm output in detail. WATADS displays products such as base reflectivity, base velocity, base spectrum width, composite reflectivity, velocity wind profile, and precipitation accumulation. Additional information displayed by WATADS includes the WSR-88D identifier, date and time of the image, the elevation angle, and the operational mode of the radar. A special feature of WATADS is its specific capabilities, such as trend windows for severe weather phenomena (e.g., hail, mesocyclones, and tornadic vortex signatures). More detailed output for these severe weather phenomena is also displayed in tabular form. In addition, the same looping, zooming, and filtering functions an operator uses with a WSR-88D system can also be done using WATADS. The user can also store and print alphanumeric output data of all of the algorithms and their adaptable parameter values. Most importantly for this research, a digital output of all of the VAD wind data can be retrieved after processing the Level II data. The WSR-88D Operational Support Facility (OSF) in Norman, OK, hopes researchers will use WATADS to improve meteorological algorithms for the WSR-88D, and improve interpretation of WSR-88D products.

d. Research objectives

The performance of the VAD algorithm, like all of the other WSR-88D algorithms, varies significantly in different operational uses and different climates. The goal of this research is to improve the operational use of this WSR-88D product by trying to find the optimal values of the VAD algorithm's adaptable parameters covering all four seasons for

a specific geographical location. The results of this research will possibly allow any WSR-88D radar operator to discover the best values of the adaptable parameters for a particular WSR-88D site.

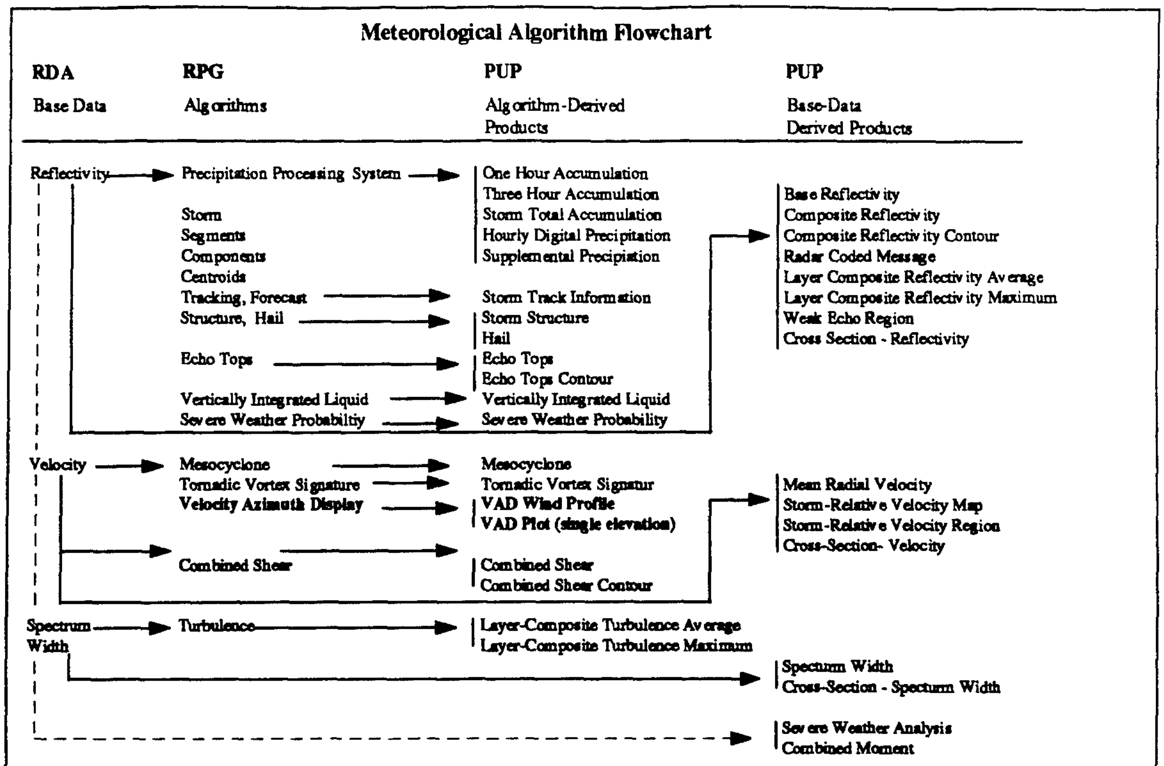


FIG. 1. Meteorological algorithms processing flow through the WSR-88D system. (From Klazura and Imy, 1993).

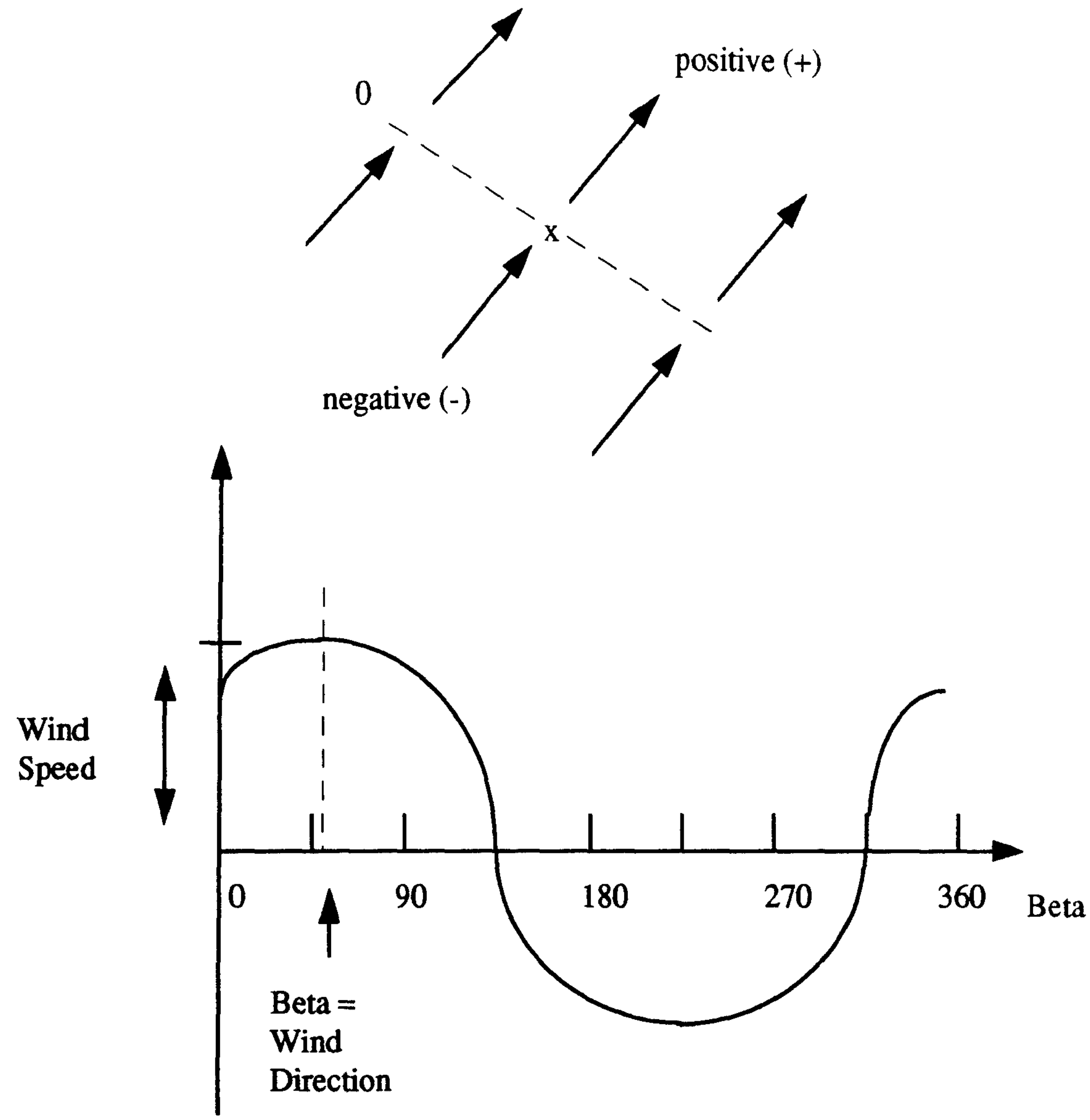


FIG. 2. How a Velocity Azimuth Display (VAD) works. In this example, the wind is from the southwest about 230 degrees (shown at top). A Doppler radar located at x would detect negative radial velocities southwest of the radar indicating winds blowing towards the radar. The radar would also detect positive radial velocities northeast of the radar indicating winds blowing away from the radar. As the radar scans 360 degrees, the radial velocity measured by the radar appears to vary sinusoidal (shown at bottom). The wind direction is determined by finding the direction from which the radial wind component is the greatest or the least. In this example, the wind is blowing towards the northeast about 050 degrees. (From Bluestein, 1992).

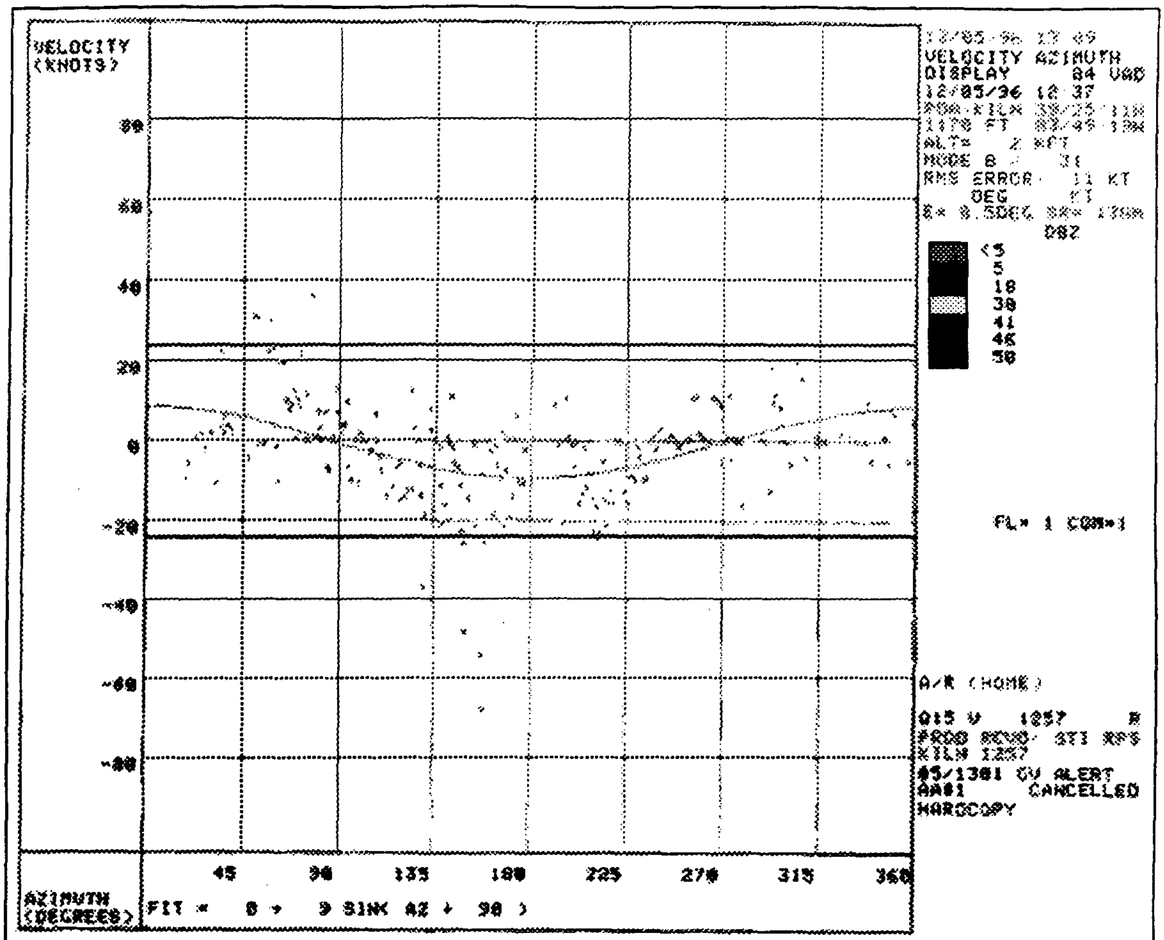


FIG. 3. Velocity Azimuth Display (VAD) from a WSR-88D system.

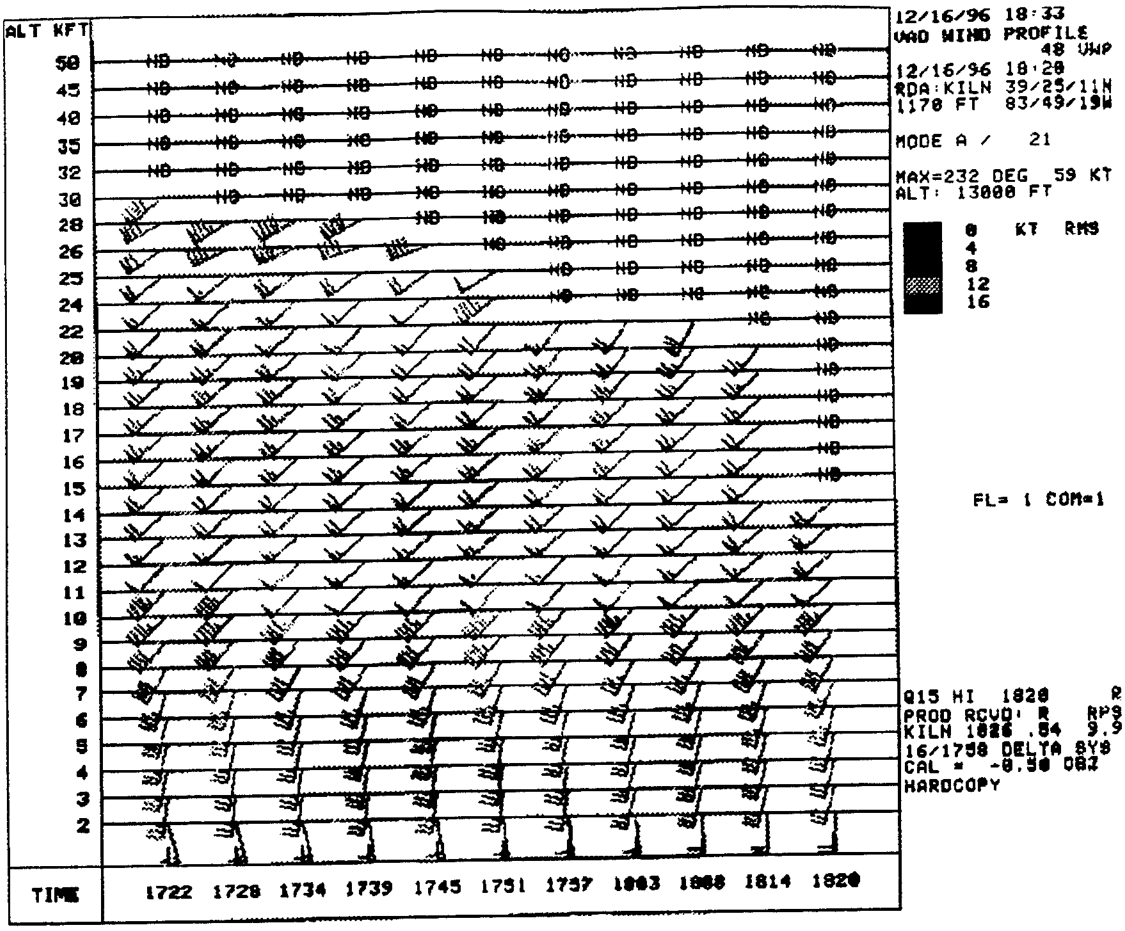


FIG. 4. Velocity Azimuth Display (VAD) product from a WSR-88D system.

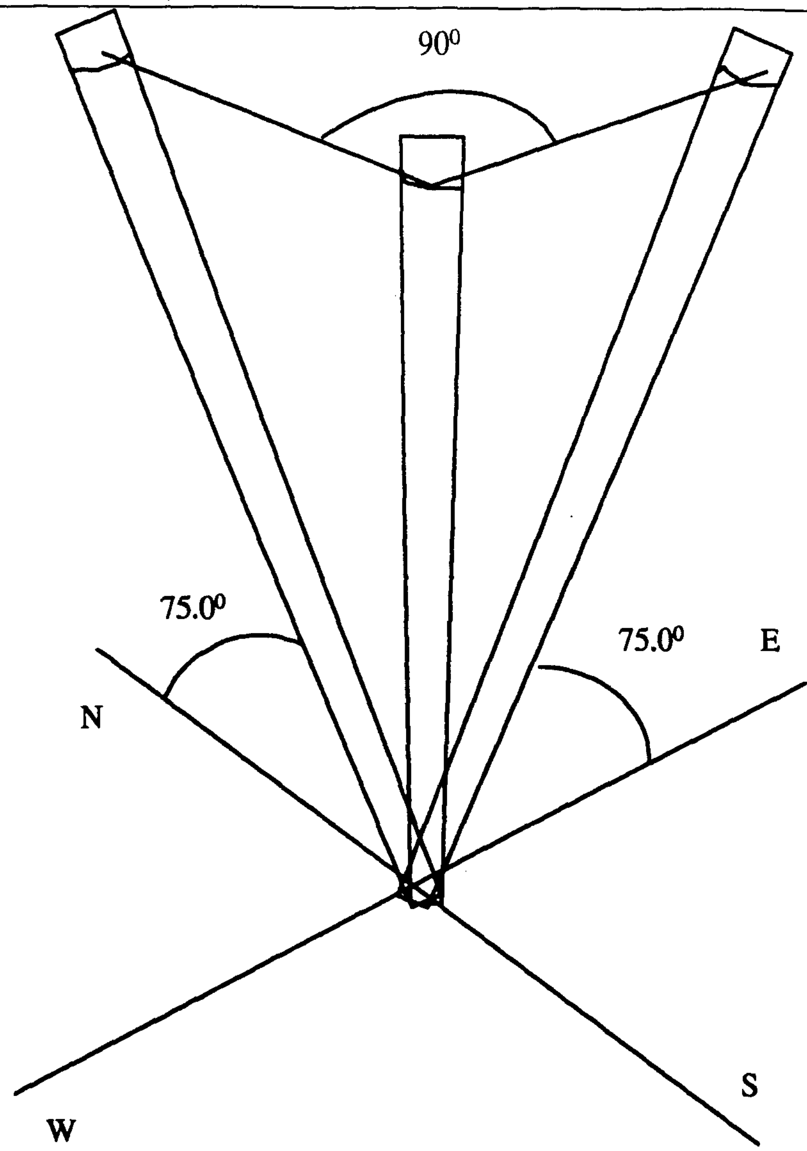


FIG. 5. Viewing angles of a Doppler-radar wind profiler. In this figure, the beams from the wind profiler are directed vertically. One beam is 15 degrees from the vertical toward the east, and the other beam is 15 degrees from the vertical toward the north. The phased array antenna is located at the ground.

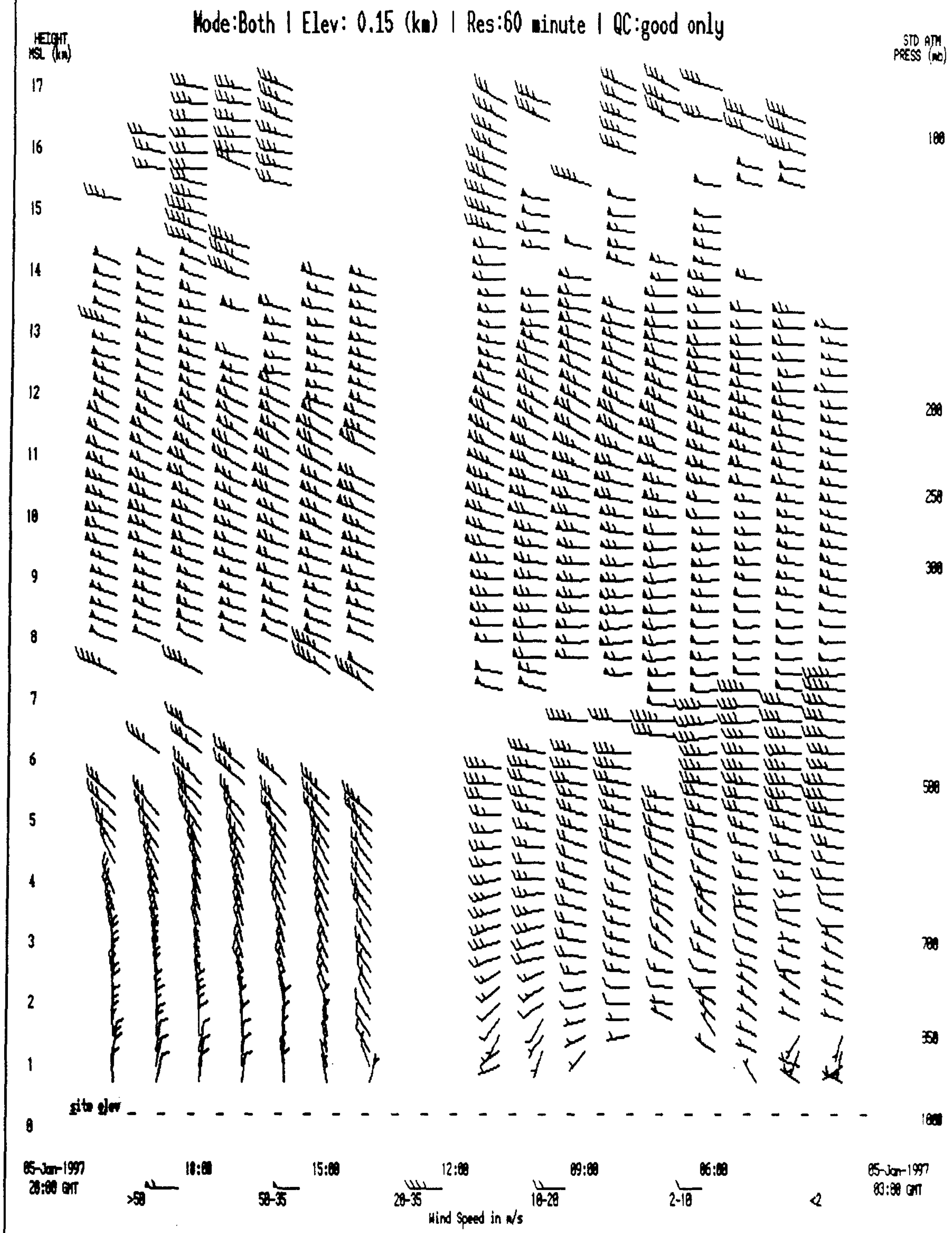


FIG 6. Output from the NOAA Profiler Network wind profiler at Vandenberg, CA.

2. Literature review

a. Possible causes of the problem

Meteorologists have reported problems with the VAD algorithm to the OSF. Several possible explanations exist for the differences in the wind data between the two types of measurements. One possible explanation is that many personnel at a significant number of sites may not be updating the radar's environmental wind table twice a day with an estimate of the environmental wind profile as the OSF has recommended. This update allows the radar to calculate the best wind data possible to provide input to all of the meteorological and hydrological algorithms. However, assuming the forecasters perform this procedure, there are still meteorological reasons why the VAD derived winds displayed by the VWP may be in error. One reason may be that there are just too few scatterers in the air for the radar to detect to calculate wind data. Another reason is certain thresholds in calculating the VAD wind data may have been exceeded, thus causing no data to be reported. Also, the radar is so sensitive while operating in the clear-air mode that migrating birds could possibly cause a bias in the wind values reported for a particular layer (Davis et al., 1995) The most likely reason for the VAD winds to be in error is that anomalous propagation (AP), which usually occurs during an inversion in the atmosphere, can cause the radar beam to subrefract, or more likely superrefract, causing the winds to be inaccurately reported for a certain height. Thus, the actual height of the radar beam may be different from the radar algorithm estimates of the height of the radar beam. The radar may be reporting wind speed and direction at height X, when actually

that particular wind data is for a different height. Figure 7 shows an example of the radar beam in a standard atmosphere and in an inversion.

Ducting of the radar beam usually occurs with nocturnal temperature inversions, or by inversions associated with boundary layer wind shift lines.

b. Recent research developments

One problem in comparing wind data from a VAD wind profile to a rawinsonde is the two systems are sampling wind motion on different scales. A rawinsonde measures winds along the trajectory of the balloon, and can be affected by features as small as a few tens of meters. Since the Doppler radar collects wind data from a range circle of 25 to 40 km radius, any small scale features are smoothed out. Since the Doppler radar beam, which has a beam width of 0.95^0, varies from 700 to 1100 m through this radius, radar beam averaging also can cause discrepancies (Stensrud, 1990). Therefore, some variations in comparing the two types of wind data should be expected.

One previous study in 1995 conducted by personnel at the OSF compared rawinsonde wind data to VAD wind profiles from the WSR-88D. They compared these two types of measurements at twelve different locations for a period of one year. Results from their research showed that the WSR-88D winds were likely to disagree with the rawinsonde wind data in fall and winter, compared to cases in summer (Davis et al., 1995). Looking more closely at the data, meteorologists at the OSF believed most of the disagreements in winter were due to meteorological inversions in the atmosphere, while disagreements in the fall were attributed to bird migrations affecting the WSR-88D wind data. One of the

recommendations suggested by the OSF was to decrease the value for the VAD range (VAD) adaptable parameter during certain meteorological conditions. Some improvement with the VAD algorithm has been noted by meteorologists using this suggestion.

Lee and Ingram (1995) tried to compare VAD wind data to wind profiler data. Unfortunately, they experienced problems with the systems and were only able to compare eight data points. However, they do believe that wind profiler data would correspond better to VAD wind data than the rawinsonde data does, since the wind profiler and VAD both almost continuously monitor the wind field above a fixed location.

Another study conducted by members of the National Oceanographic and Atmospheric Administration (NOAA) in 1989 compared rawinsonde wind data to wind profiler measurements twice a day over a two year period. They concluded the two types of measurements showed much closer agreement than they expected, and that the small differences were mainly due to meteorological noise (Weber and Weurtz, 1990).

Since wind profilers and rawinsondes also measure winds in very different ways, comparisons between these two systems can also be difficult. Unlike the rawinsonde balloon, the wind profiler samples a much larger volume because of time integration involved in an individual sample and in an hour average (Weber et al., 1990). For the rawinsonde, during strong winds the rawinsonde balloon can travel many kilometers away from the point of release, thus the measurements made at different altitudes are not made directly above one another, and would be far from the location of the wind profiler (Weber et al., 1990). However, comparisons between the two systems are usually good in

conditions of uniform winds, when there are no significant changes in the winds over an hour, and the distance between the two instruments is small.

Nelson (1994) conducted a routine intercomparison between VAD winds, rawinsondes, and wind profilers, along with other wind measuring systems. He concluded that there was good agreement between the wind profiler and rawinsonde data. Nelson's research also showed fair agreement between the VAD and rawinsonde data and fair agreement between the VAD and wind profiler data. However, the differences between the systems did not agree as well as the comparisons in Weber's study. A significant difference between the statistical comparisons of that study compared to this thesis, is that digital wind values from the VAD algorithm were not available. VAD wind direction and wind speed values used in Nelson's comparisons were manually interpreted from the VWP product on the radar screen . For this thesis, the WATADS software produces an output file with the digital wind values, so the comparisons in this thesis should be slightly more accurate.

It will be difficult to make a meaningful comparison in this thesis with all of the other studies because the data was collected for a different location, during different seasons, and for different lengths of time. Nevertheless, comparisons between these three types of data are informative and can be a starting point for other important research.

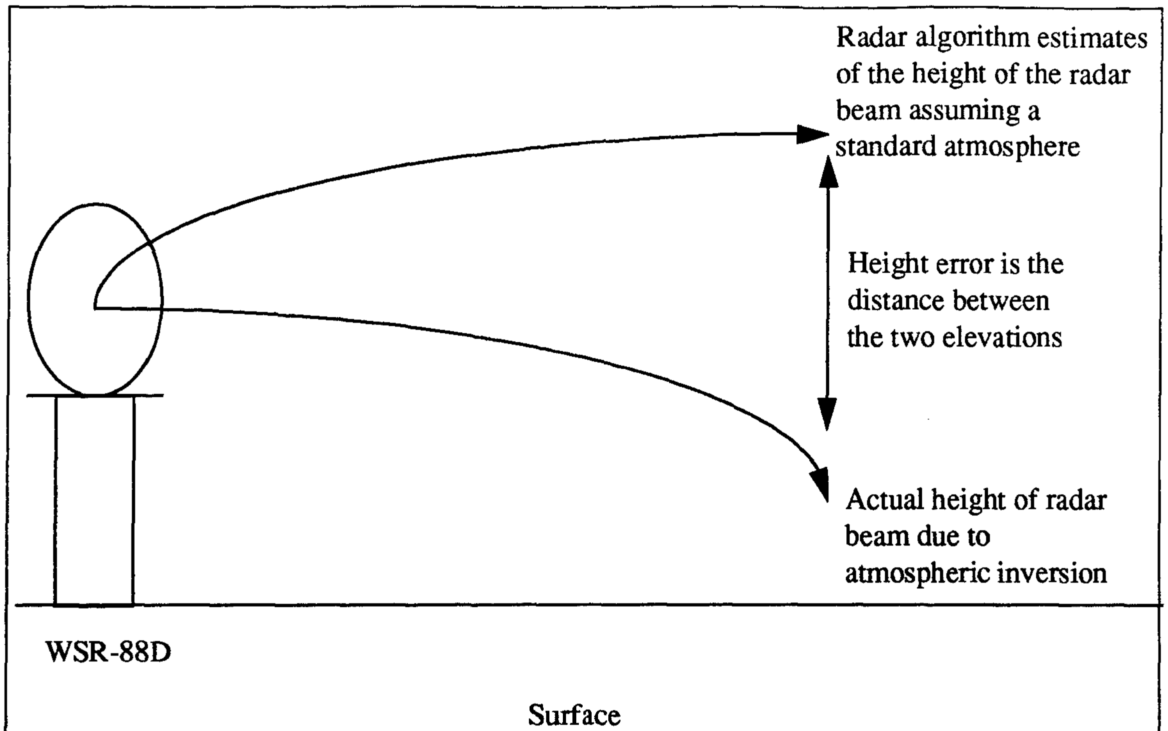


FIG 7. Representation of height errors due to bending of the radar beam in an inversion.

3. Methodology

a. Objectives

The objective of this research is to find optimal values for the adaptable parameters of the VAD algorithm for Vandenberg AFB, CA.

b. Scope

For this research, wind data was collected for Vandenberg AFB, CA. from November 1995 through July 1996. This site was chosen because this location has a WSR-88D system, a rawinsonde sounding, and a wind profiler, all collocated within a twenty-five mile radius. These three types of data were chosen so that comparing the new wind data created by changing the adaptable parameters of the VAD algorithm with the two other sources of wind data should give a statistically more accurate result, and enable more reliable conclusions to be drawn. Corresponding ground truth data, such as hourly station observations were also collected for Vandenberg AFB to determine the weather conditions for each day (such as inversions or precipitation). This particular time period was chosen to give wind data representing all four seasons. November 1995 is the beginning of the time period because NEXRAD Level II data from Vandenberg AFB was not archived at the National Climatic Data Center (NCDC) in Asheville, NC, before this date.

For each season, the large amount of wind data was narrowed to focus in on approximately two weeks in each season. This minimized the number of NEXRAD tapes

needed to be processed by the WATADS software. Each tape contains about two days of data, and it takes approximately six to nine hours of real time to process each tape using WATADS on a Sparc 20 machine. Each of the time periods selected has a wide range of meteorological conditions, but usually an inversion at some level in the atmosphere is present. The goal is to determine the optimum parameter settings of the VAD algorithm for each season at this location.

1) DATA COLLECTED FOR RESEARCH

The first step in this process was ordering rawinsonde data and wind profiler data from the (NCDC) for November 1995 through July 1996. Since the main assumption in this thesis is that the major source of discrepancy between the three types of wind data is caused by inversions in the atmosphere, the rawinsonde data was then used to help decide which dates to examine more closely. A computer program was created to list all of the low-level inversions below 900 mb for each sounding in the time periods for each season. An average depth of these low-level inversions was also calculated. All of the soundings were then reexamined to highlight all soundings with an inversion depth greater than the average depth of the low-level inversions. The soundings were then grouped by a period of 14 soundings (approximately a week's worth of data). If this particular group had more than seven soundings with inversions greater than the average depth, this group of 14 soundings was highlighted. The selected groups of soundings with strong inversions were then compared with corresponding surface data from Vandenberg AFB to find the group with the widest range of surface weather. Two groups of 14 soundings were then

chosen for each season. Some additional soundings near the beginning or ending of each period were added, if necessary, for continuity of weather conditions. Six soundings from each season except for fall, which only had three, were manually plotted to show the strength of the inversions in each season. The soundings in the summer showed the strongest inversions in temperature increase and in depth, while the soundings in the winter season showed the weakest inversions. The strength of the inversions in the fall and spring seasons were about equal with both strong and weak inversions. The wind profiler data was then simplified to match the dates of the selected rawinsonde data. NEXRAD Level II data tapes for these same dates were then ordered from the NCDC. Thus, all three types of wind data were reduced to specific periods in each season. Table 1 shows the dates chosen for Vandenberg AFB for this research.

The data in the fall season only covers three days because of the availability of NEXRAD Level II data tapes from Vandenberg AFB for this period.

At Vandenberg, the rawinsonde, wind profiler, and WSR-88D radar are all located within twenty miles of each other. Table 2 gives the location and elevation of each type of wind measuring system at Vandenberg.

Since the WSR-88D is located at a much higher altitude than the wind profiler and rawinsonde, it is possible that if there was a shallow low-level inversion below 400 m the radar beam would completely overshoot the inversion. Thus, the VAD wind data would not reflect the real meteorological conditions.

2) Quality Control of Data

Although the possible errors in the different types of wind data were mentioned in Chapter 1, it is assumed for this research that all of the wind data received from each of the three types of data is valid. The wind profiler data goes through its own quality control checks before being output. The VAD wind data has a Root Mean Square (RMS) error that indicates possible unreliable data. However, a visual check of all of the tabular VAD wind data produced by WATADS for these selected dates showed no significantly high RMS values. The rawinsonde wind data is accepted as truth even though it is subject to the errors mentioned in the previous chapter. Therefore, all measurements from all three data sources are included in the comparisons in this thesis.

3) Treatment of Missing Data

Each of the three wind data sets were run through a computer program to remove all missing values, so that comparisons between the three data sets would only be made for actual wind values.

4) Using the Variable Terrain Radio Parabolic Equation (VTRPE) Computer Model Software

The Variable Terrain Radio Parabolic Equation (VTRPE) computer model software was used to compare radar beam propagation in a standard atmosphere to radar beam propagation in an atmosphere with an inversion. The VTRPE model allows users of radar-based systems to determine the effects of terrain and the environment on a radar

beam propagating through the atmosphere.[4] The VTRPE model was used because it is assumed the major source of error in the WSR-88D wind data is due to errors in calculating beam height. Since the WSR-88D's VAD algorithm assumes the radar beam is propagating through a standard atmosphere, this software gave a better understanding how the radar beam changes with height, and provided insights into how the values for each of the adaptable parameters could be changed to correct this problem.

Output from the VTRPE was studied to discover how a radar beam propagates through a standard atmosphere, and how the beam propagates through an atmosphere with an inversion. Figure 8 shows an example of output from the VTRPE software.

c. Experimental procedure

The first step in this research was to process all Level II data tapes with the unmodified adaptable parameters to get original VAD wind data. A statistical correlation was then conducted between each of the three data sets: the original VAD wind data, the rawinsonde upper air sounding wind data, and the wind profiler wind data. Chapter 4 discusses the results of each statistical correlation between the data sets.

The next step was to calculate new VAD wind profiles from modified adaptable parameters using the WATADS software. This allowed the researcher to discover which values work the best for each adaptable parameter.

[4] From "Variable Terrain Radio Parabolic Equation." WWWeb, http://laurel.wpafb.af.mil/ascspt.html (18 Sep 96)

d. Results

The major source of discrepancy in the original statistical correlation between the three types of data is assumed to be due to atmospheric inversions. Using the VTRPE plots of the radar beam in an inversion compared to a radar beam in a standard atmosphere, decisions can then be made as to how to adjust each adaptable parameter of the VAD algorithm to find its optimum value.

Of the seven different adaptable parameters, only the modification of the range parameter has any physical significance on how the WSR-88D VAD algorithm would calculate the wind data. Increasing or decreasing the range value adaptable parameter can affect which specific heights the radar beam will use to calculate winds. For example, the radar beam at 0.5 degrees elevation scan will detect less scatterers in the atmosphere with a range value of 20 km compared to a range value of 30 km. Changing the values of all of the other parameters adjusts the statistical curve fitting procedure used by the algorithm. Changing the statistically oriented adaptable parameter might yield some small improvement; however, the chances are increased that valid wind data will be ignored.

The OSF has suggested decreasing the VAD range as one possibility to improve the VAD algorithm during an inversion; therefore, the main focus of this research is to improve the VAD winds for Vandenberg by finding optimal values of the adaptable parameters for the VAD algorithm at this location.

1) OPTIMIZATION OF THE ADAPTABLE PARAMETERS

Table 3 below shows how a researcher can change the adaptable parameters of the VAD algorithm.

WATADS allows a wider range of values for the adaptable parameters in case future research proves that the WSR-88D values need to be modified. The following states how the values for each adaptable parameter were changed for this research.

(i) (VAD) - VAD range

The VAD range parameter was varied in increments of 2.0 km. Since the OSF recommended decreasing the range value from the default value of 30.0 km, the VAD range was lowered to values of 28.0, 26.0, 24.0, 22.0, and 20.0 km. The adaptable parameter was also increased to a value of 32.0 km to check for any improvements.

(ii) (TBZ/TEZ) - Beginning and ending azimuth thresholds

These adaptable parameters were not changed since some of the comparisons had low sample sizes. Eliminating sectors of data would have reduced the sample size even further. It is believed that changing the values of these parameters would only make the VAD wind data worse since valid wind data would be eliminated from the selected azimuths. Another reason these parameters were not changed was because an accurate knowledge of the surrounding topography could not be obtained. Thus, it could not be determined if any specific sectors surrounding Vandenberg were causing any problems with the radar beam.

(iii) (THV) - Threshold velocity

The value of this adaptable parameter was decreased from the default value of 5.0 by an increment of 2.0 to a value of 3.0, and increased by an increment of 2.0 to a value of 7.0.

(iv) (THY) - Threshold symmetry

The value of this adaptable parameter was decreased from the default value of 7.0 by an increment of 2.0 to a value of 5.0, and increased by an increment of 2.0 to a value of 9.0

(v) (FT) - Number of fit tests

The value of this adaptable parameter was decreased from the default value of 2 by an increment of 1 to a value of 1, and increased by an increment of 1 to a value of 3.

(vi) (NPTS) - Minimum number of samples

The value of this adaptable parameter was decreased from the default value of 25 by an increment of 5 to a value of 20, and increased by an increment of 5 to a value of 30.

2) DATA ANALYSIS AND INTERPOLATION

Each change in the value of an adaptable parameter generated a new set of VAD wind data. The unmodified VAD wind data was compared to the rawinsonde data and wind profiler data and is discussed in Chapter 4. This data was used as a baseline against which to compare the modified VAD wind data. The modified VAD wind data compared to the

wind profiler data is discussed in Chapter 5, and the modified VAD wind data compared to the rawinsonde data is discussed in Chapter 6.

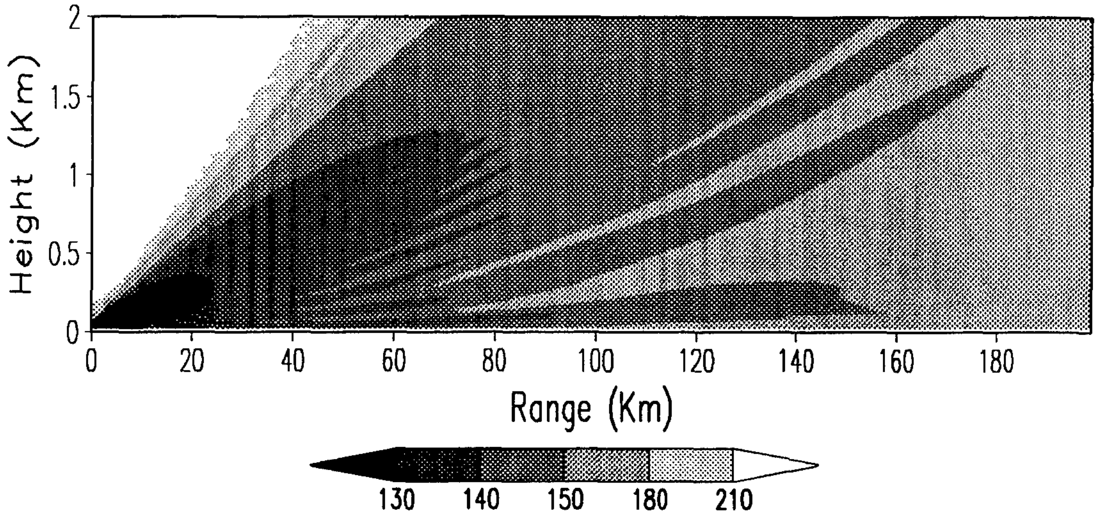


FIG 8. Output from the Variable Terrain Radio Parabolic Equation software for a radar at Vandenberg. In this figure, the white area in the upper left corner is the radar's cone of silence. The shaded area just above the surface shows the radar beam being ducted.

TABLE 1. Selected dates to use for research at Vandenberg AFB.

Vandenberg AFB data	Selected dates
Fall	29 Nov 95, 00Z to 1 Dec 96, 12Z
Winter	27 Jan 96, 00Z to 7 Feb 96, 12Z
Spring	17 Mar 96, 00Z to 27 Mar 96, 18Z
	21 Apr 96, 06Z to 29 Apr 96, 00Z
Summer	11 Jul 96, 00Z to 31 Jul 96, 00Z

TABLE 2. Location and elevation of sources of wind data at Vandenberg, CA.

Vandenberg	Elevation (ft) msl	Elevation (m)	Latitude/Longitude
WSR-88D	1321	402.6	34'50 N, 120'23 W
Wind Profiler	490	149.3	34'46 N, 120'32 W
Rawinsonde	342 (0000 UTC) 360 (1200 UTC)	104.2 (0000 UTC) 109.7 (1200 UTC)	34'49 N, 120'34 W

Note: The 0000 UTC sounding is usually launched from a location nearby, but different from where the 1200 UTC sounding is launched.

TABLE 3. Adaptable parameter thresholds of the VAD algorithm for WATADS and the WSR-88D.

Parameter	Value	Defaul	Overall range	88-D range
(VAD) VAD Range (km)	30.0	30.0	0.1 to 230.0	1.0 to 230.0
(TBZ) Threshold Beginning Az (deg)	0.0	0.0	0.0 to 359.0	0.0 to 359.0
(TEZ) Threshold Ending Az (deg)	0.0	0.0	0.0 to 359.0	0.0 to 359.0
(THV) Velocity Threshold (m s^{-1})	5.0	5.0	0.0 to 100.0	0.0 to 15.0
(THY) Threshold Symmetry (m s^{-1})	7.0	7.0	0.0 to 30.0	0.0 to 20.0
(FT) Fit Test	2	2	1 to 10	1 to 5
(NPTS) Data Points Threshold	25	25	0 to 365	1 to 360

4. Comparisons of unmodified VAD wind data to wind profiler and rawinsonde data

a) Unmodified WSR-88D VAD wind data and wind profiler comparisons

A computer program identified matching dates, times, and heights for each season between the VAD wind data and the wind profiler data and produced paired data for a statistical analysis. The program compared the date from the VAD data to the date from the wind profiler data. Once a matching date was found, the program checked for matching times. Wind profiler data was usually reported at the top of every hour, (e.g. 0400 UTC). If the time for the VAD data was within 6 minutes on either side of the top of the hour, the program identified a match. Therefore, it was possible to have two matches of VAD data with one wind profiler data. However, this was acceptable since the wind direction and speed values of the VAD data from either side of the hour were different from each other, and thus did not represent redundant data. Once matching dates and times were identified, the program searched for matching heights. Heights from the VAD wind data were checked against heights from the wind profiler data every 250 m over the range from 500 m to 6000 m. A matching height threshold of 150 m was used for the VAD wind data. For example, if a VAD height was within 150 m above or below the wind profiler height, the computer program identified a match. Table 4 shows the number of matches identified for each season between the VAD wind data and the wind profiler data.

Once the matches were identified between each data set, the matching data was written to a separate file. A statistical analysis was then performed on the matching data for each season. First, the Root Mean Square Vector Difference (RMSVD) (Davis et al., 1995) was calculated. The RMSVD is a single scalar value which indicates the agreement or disagreement between the two different types of wind data. The RMSVD was calculated for all of the comparisons in this research to compare the results with the previous study conducted by the OSF mentioned in Chapter 2. The RMSVD equation is listed in appendix A.

Next, a separate scatterplot was made for the u component and the v component at each height from 500 m to 6000 m. Then, the Pearson correlation coefficient (r), and the coefficient of determination (r^2) were calculated for each u and v component at every height. The Pearson correlation coefficient (r) is the ratio of the sample covariance of two variables (x and y) to the product of the two standard deviations (Wilks, 1995). The correlation coefficient measures the strength of any linear relationship between the u components of the VAD data and the u components of the wind profiler data. The same calculation was also performed for the v components. However, the values of (r) must be interpreted with care since a value near zero is not evidence of a lack of a strong relationship between the two types of data, but only the absence of a linear relation. Also, the correlation coefficient can be sensitive to one or several outliers (Wilks, 1995). The (r^2) value gives the value of the coefficient of determination which would result from fitting a simple linear regression model. The coefficient of determination specifies the

proportion of the variability of one of the two variables (x or y) that is linearly accounted for by the other variable (Wilks, 1995).

After (r) and (r^2) were calculated, a two tailed t-test was then computed using (r) to assess the strength of any positive or negative correlation between the u components of the two types of data and between the v components of the two types of data. In this case, (r) measures the extent to which there is a linear relationship between the u and v components of the VAD data and the wind profiler data. For this test, the null hypothesis is H_o: (ρ) = 0, stating there is no linear relationship between the u components or the v components of the two types of data. The level of significance (α) for this test was chosen to be 0.05. The t-star, t-critical, and P-value were calculated to determine if the null hypothesis should be rejected. If the P-value was less than the level of significance (α), then the null hypothesis was rejected. The t-star value was compared to the t-critical value to verify the decision. If the resulting P-value was small, this indicates that even though the value of the correlation coefficient (r) may be small, the correlation may still possibly be statistically significant for this research. The values for all of these calculations for the comparison between the wind profiler and the VAD (unmodified) wind data can be found in the table in appendix B.

The next comparison between the VAD data and the wind profiler data examined differences in the u and v components from the two types of wind data. For each season, the u components and v components were plotted separately over time at each height

level. Figure 9a shows an example of a plot of the u component at 500 m during Spring at Vandenberg. Figure 9b shows the plot for the corresponding v component.

This type of plot was used at each height to identify periods when the VAD data and the wind profiler data were in agreement or disagreement. Areas of significant disagreement were identified, and the rawinsonde sounding for that time period was plotted. The soundings were examined to determine the location and strength of the inversions in the atmosphere. Corresponding surface data was also checked to determine the meteorological conditions present during these periods. After examining these soundings, decisions were made as to how each adaptable parameter could be changed to produce new VAD wind data which would hopefully be in better agreement with the wind profiler data.

1) RESULTS OF UNMODIFIED VAD WIND DATA/WIND PROFILER COMPARISON

The statistical data showed that the winter season showed the best agreement between the VAD wind data and the wind profiler data. This is probably due to the selected data from the winter season having the weakest inversions. Figure 10a and 10b show the (r^2) value of the u and v component, respectively, with height.

An examination of Figure 10a and 10b shows a majority of the (r^2) values at each height are higher during the winter season. Table 5 shows the average (r^2) values for both the u-component and the v-component from all heights are the highest in the winter season. Winter also has the second lowest average RMSVD value. The lowest average RMSVD value occurs during the fall; however, since there were only three days examined

during this season, the winds could have been below the normal values for the fall season at Vandenberg during this period.

b) Unmodified WSR-88D VAD wind data and rawinsonde comparisons

This research next examined matches between the VAD wind data and the rawinsonde data. The VAD data was considered a match with the rawinsonde data if the time for the VAD data was within six minutes on either side of the top of the hour of the rawinsonde time. Then, heights from the VAD wind data were checked against heights from the rawinsonde data every 300 m over the range from 600 m to 6000 m. A matching height range of 150 m was again used for the VAD wind data. Table 6 shows the number of matches identified for each season between the VAD wind data and the rawinsonde wind data.

The number of matches is small for the comparison between the VAD data and the rawinsonde data; however, this is because usually the rawinsonde is launched only twice a day. Since there are only a small number of matches, any conclusions drawn from the calculated statistics must be considered carefully. The statistics from this comparison between the rawinsonde and VAD were compared to the statistics from the comparison between the wind profiler and VAD to determine which system the VAD wind data agrees with more.

1) RESULTS OF UNMODIFIED VAD WIND DATA/RAWINSONDE COMPARISONS

The statistical data showed the winter season to have the best agreement between the VAD wind data and the rawinsonde data. Like the previous comparison between the

VAD wind data and the wind profiler, this is due to the winter season having the weakest inversions. Figure 11a and 11b show the (r^2) values of the u and v component respectively with height.

An examination of Figure 11 and Table 7 shows similar results to the comparison between the wind profiler and VAD wind data. The comparison between the rawinsonde and the VAD wind data shows the winter season to have the highest average (r^2) values. Also, the winter season has the second lowest average RMSVD value again.

c) Rawinsonde and wind profiler comparisons

The last part of this research examined matches between the rawinsonde data and the wind profiler data. Wind profilers report wind data one hour after the start of measurement. For example, winds reported at 1200 UTC are the winds averaged by the wind profiler from 1100 to 1159 UTC. Rawinsondes are launched twice daily, usually between 1100 and 1300 UTC, and again between 2300 and 0100 UTC. For this research, the rawinsonde data was compared to the wind profiler data averaged from 1100 to 1200 UTC, and from 2300 to 0000 UTC.

Unfortunately, comparisons for these two data sets were extremely poor. For the winter season, there were no matches at all. A manual examination of the data for all of the seasons discovered that the archived wind profiler data from Vandenberg for the selected dates did not report any data at 0000-0200 UTC or 1200-1400 UTC. Officials at the Vandenberg base weather station were contacted and they reported that the radio frequency of both the profiler and rawinsonde is 404 MHz. Thus, the profiler is turned off

whenever a rawinsonde balloon is scheduled to be launched. However, the computer program did locate at least 1 matching date and time between these two types of data in each season (except winter). Matching times from all of the data were at 0600, 1600, 1800, or 1900 UTC. No explanation could be determined why a match occurred at these particular times, since the profiler theoretically should have been off. Therefore, any conclusions drawn from this comparison between the rawinsonde data and the wind profiler data must be carefully considered and need to be substantiated in further research. Vandenberg officials at the base weather station stated that the wind profiler is scheduled to be upgraded to 449 MHz in 1997, so a more accurate comparison between these two types of data can be made once this upgrade occurs.

For the matching dates and times that were identified, heights from the rawinsonde data were checked for height matches from the wind profiler data every 250 m from 500 m to 6000 m. As with the VAD wind data, a matching height range of 150 m was used for the rawinsonde wind data. Table 8 shows the number of matches identified for each season between the rawinsonde wind data and the wind profiler data.

Since the number of matches is extremely low, any conclusions drawn from this comparison must be carefully considered.

1) RESULTS OF RAWINSONDE/WIND PROFILER DATA COMPARISON

Since the only statistical data from the comparisons between the rawinsonde data and the wind profiler data was for the spring season, it is assumed that these results are typical of the other seasons as well, although this may not be an accurate assumption. Data for

different time periods may have yielded more data for each season. The plots of the u and v components over time at each height showed that the single points from the rawinsonde data and the wind profiler data were usually very close to each other. Figure 12a and 12b shows the (r^2) values of the u and v component respectively with height.

For this comparison between the rawinsonde and wind profiler data, in all seasons the number of matched pairs was usually zero, one, or two. Thus, the correlation coefficient (r) and the coefficient of determination (r^2) were not calculated since these values would be zero, one, or infinite, respectively.

The only season with enough matches to calculate (r^2) values was the spring season. Figure 12 and Table 9 does show that the average (r^2) value for the u-component is the highest of any of the other two comparisons in Table 7 or Table 8, and the average (r^2) value for the v-component is the second highest of all the comparisons. However, since the number of data points is extremely small, the level of confidence in these results are very low. As in the other comparisons, the fall season has the lowest average RMSVD value. However, the average value for summer is also small, possibly because of lighter winds at Vandenberg during this season.

d) Summary of comparisons with unmodified VAD wind data

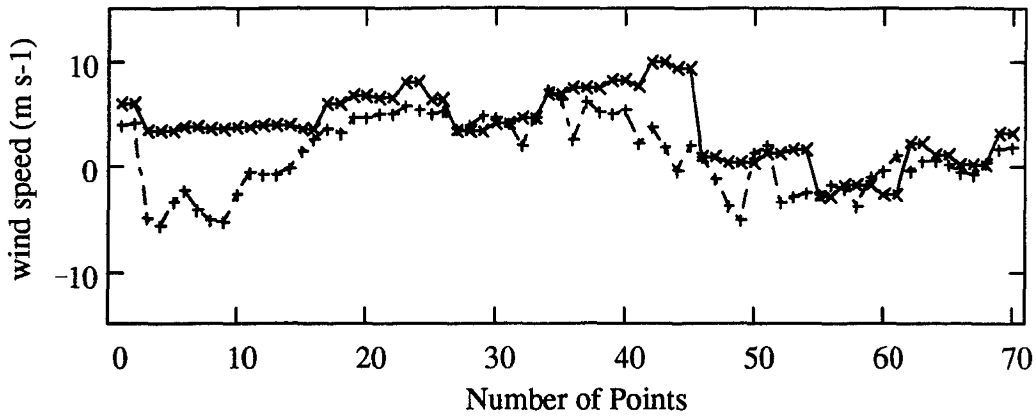
The data indicates the best overall correlation is between the rawinsonde data and the wind profiler data, compared to the VAD/profiler data , or the VAD/rawinsonde data, although this conclusion is made on the extremely low sample size between the rawinsonde and wind profiler data. This is not a good conclusion due to the sample size

between the rawinsonde and wind profiler having only four data points. However, assuming that a larger sample size would show that the rawinsonde and wind profiler have the highest average (r^2) values during inversions for all seasons, then it can also be understood that the VAD wind data would be the wind profiling system most likely to be different and most likely inaccurate during these inversions. This is one of the main reasons why the optimal values for the adaptable parameters of the VAD algorithm need to be determined.

New VAD data can be produced by using WATADS to change the adaptable parameters that would improve the correlation coefficients between the VAD wind data and the two other systems.

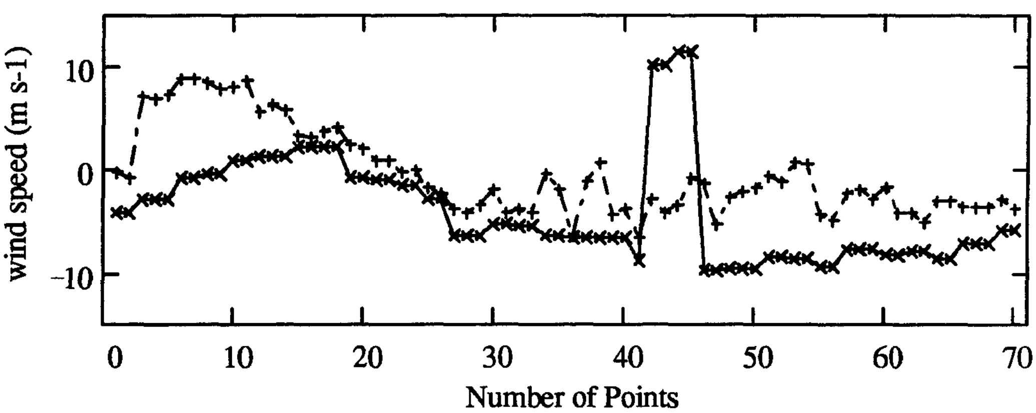
All statistics computed between the wind profiler, rawinsonde, and unmodified VAD wind data discussed in this chapter were used as a statistical baseline to compare with the new statistical data created from the new modified VAD wind data generated by WATADS. The dates and times of the matches are the same as the original data set. The number of matches for all of the data groups in each season are the same at some height levels, but different for other heights. This is due to how the WSR-88D processes the wind data from using the different elevation angles to determine the height of the wind data. As with the comparisons discussed in this chapter, most of the statistics were not calculated if the new number of matches between the new comparisons was zero, one, or two. Chapter 5 of this thesis discusses the new modified VAD wind data generated from changing the adaptable parameters of the VAD wind data compared to the wind profiler

data. Chapter 6 discusses the new modified VAD wind data compared to the rawinsonde data.



Wind profiler (x), VAD (+)

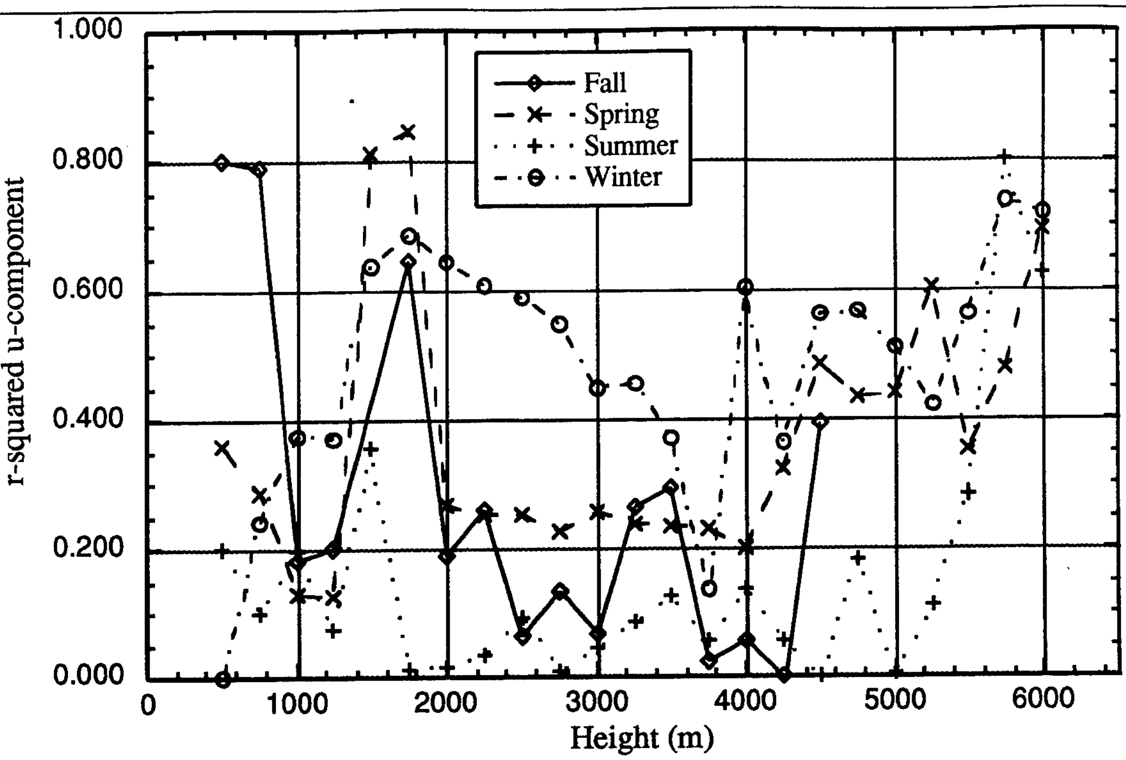
(a)



Wind profiler (x), VAD (+)

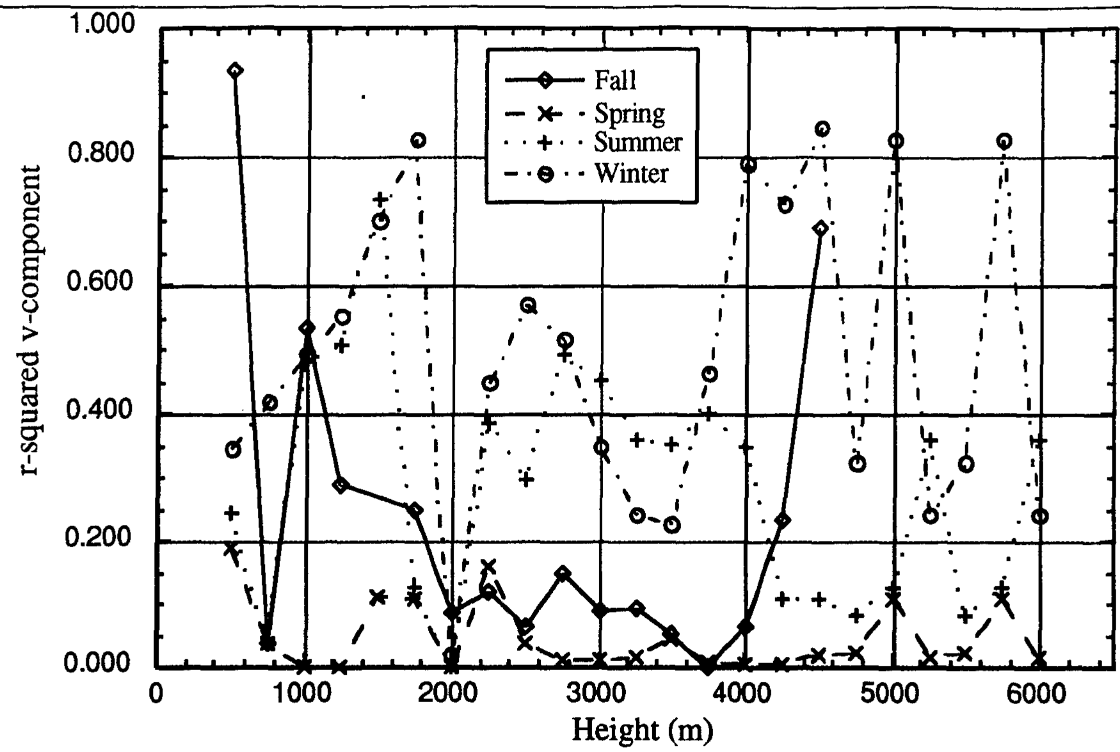
(b)

FIG 9. Comparison of wind profiler and VAD wind (unmodified) components at Vandenberg in spring 1996 at 500 m height: (a) u-component; (b) v-component.



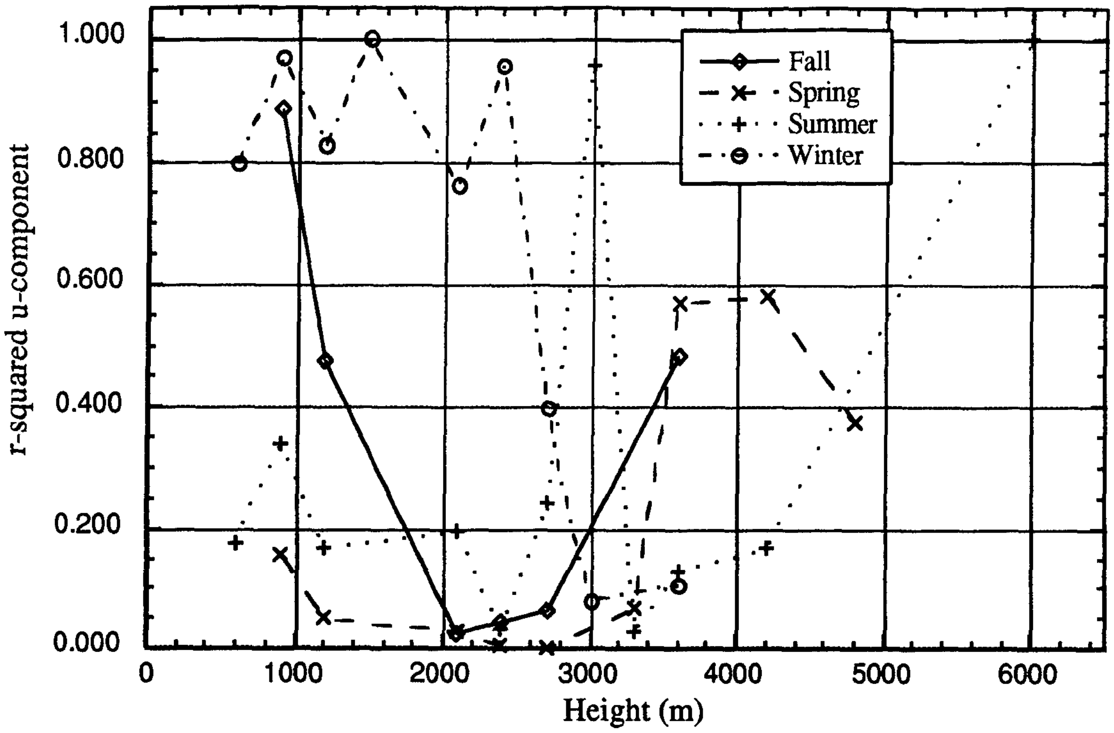
1.000
0.800
0.600
0.400
0.200
0.000
r-squared u-component
0
1000
2000
3000
4000
5000
6000
Height (m)
Fall
Spring
Summer
Winter

(a)



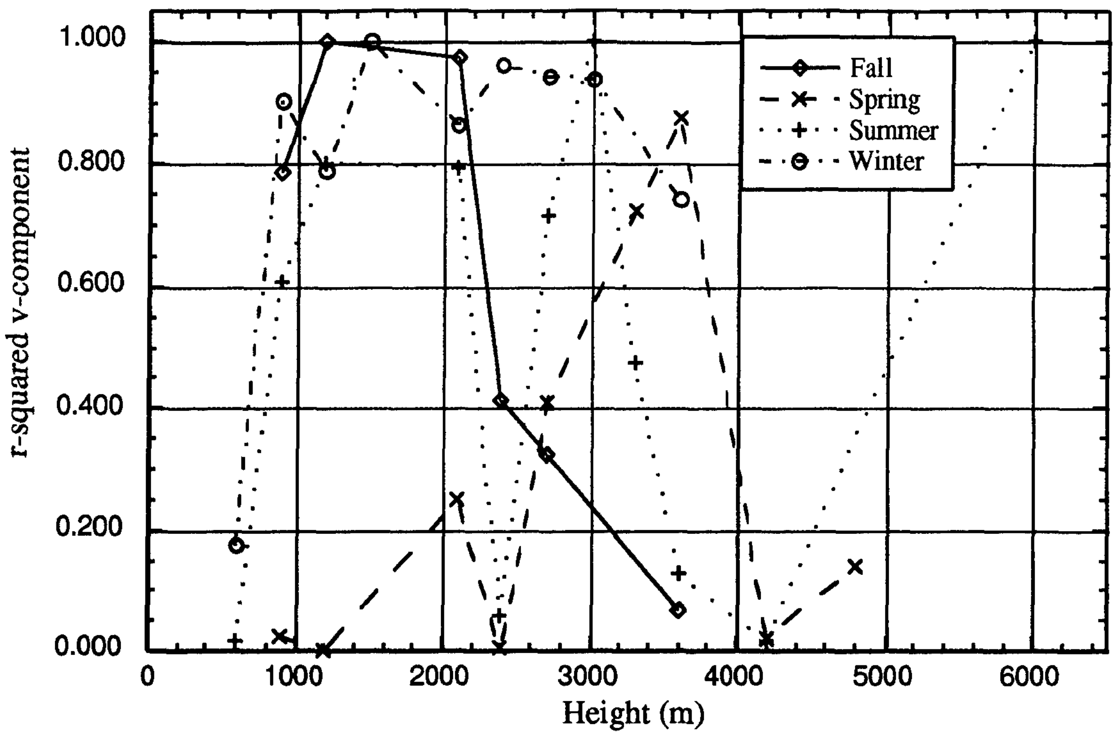
(b)

FIG 10. Coefficient of determination (r^2) with height between the wind profiler and VAD (unmodified) wind data for all seasons at Vandenberg: (a) u-component; (b) v-component. Note: Some heights will not have a plot if (r^2) could not be computed due to zero, one, or two matches.



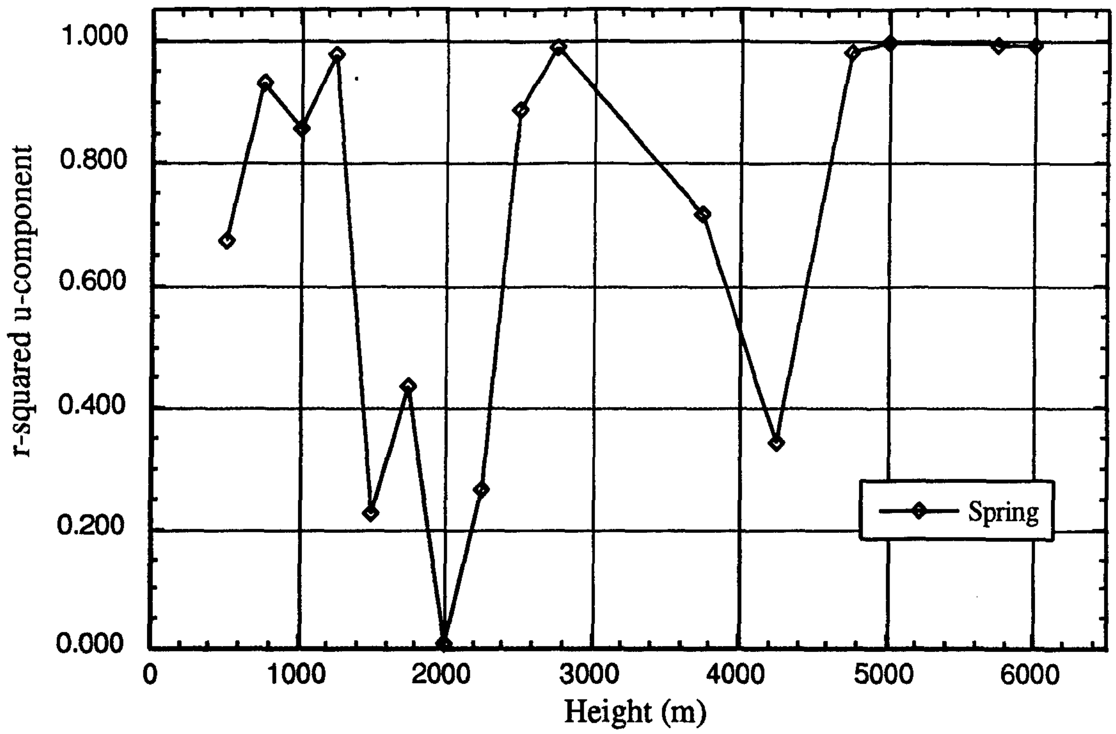
1.000
0.800
0.600
0.400
0.200
0.000
r-squared u-component
0
1000
2000
3000
4000
5000
6000
Height (m)
Fall
Spring
Summer
Winter

(a)

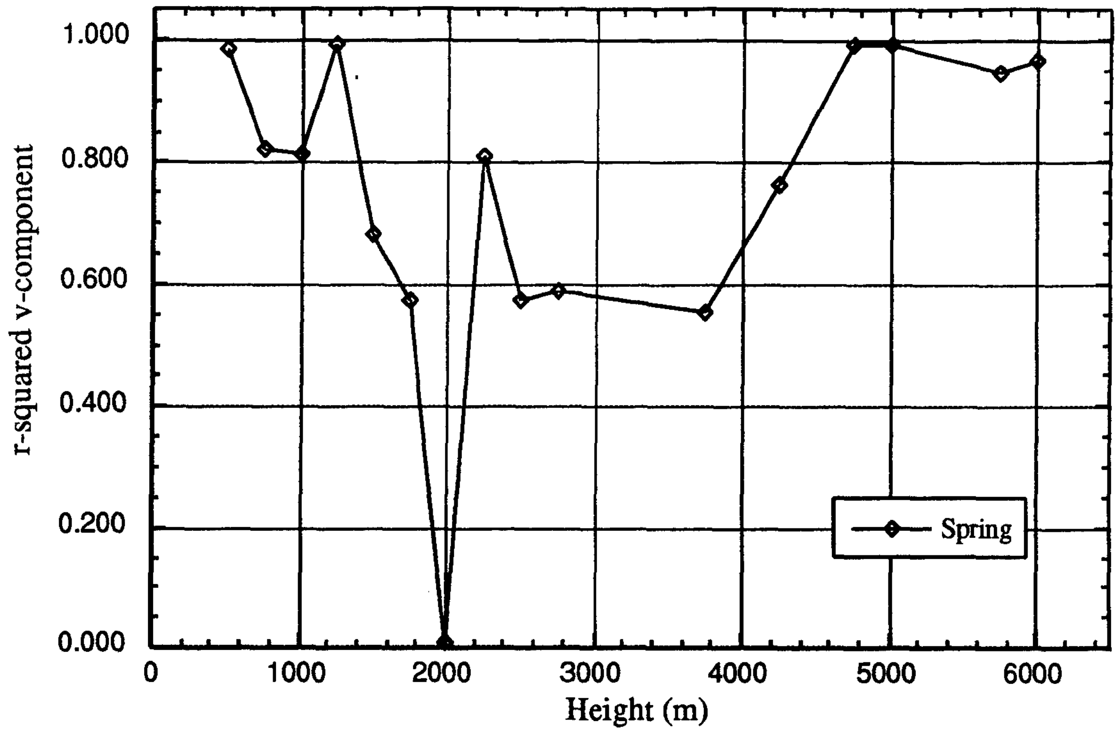


(b)

FIG. 11. Coefficient of determination (r^2) with height between the VAD wind (unmodified) and the rawinsonde data sets for all seasons at Vandenberg: (a) u-component; (b) v-component. <u>Note:</u> Some heights will not have a plot if (r^2) could not be computed due to zero, one, or two matches.


1.000
0.800
0.600
0.400
0.200
0.000
r-squared u-component
0
1000
2000
3000
4000
5000
6000
Height (m)
Spring

(a)



(b)

FIG. 12. Coefficient of determination (r^2) with height between the rawinsonde and wind profiler: (a) u-component; (b) v-component. Note: Some heights will not have a plot if (r^2) could not be computed due to zero, one, or two matches.

TABLE 4. Number of matched pairs between the wind profiler and VAD wind (unmodified) data sets.

Season	Fall	Spring	Summer	Winter
Total profiler observations	10723	22769	14229	14410
Total VAD observations	2445	21582	18618	17962
Height (m)				
500	4	70	106	252
750	4	70	106	257
1000	43	380	353	267
1250	37	344	309	189
1500	1	36	35	144
1750	3	31	29	127
2000	24	392	254	191
2250	24	393	254	187
2500	22	363	225	166
2750	31	276	217	122
3000	34	244	203	110
3250	22	216	189	102
3500	22	217	187	102
3750	38	201	169	108
4000	23	186	140	87
4250	11	201	141	90
4500	6	144	87	81
4750	0	124	36	80
5000	0	132	40	80
5250	0	91	12	93
5500	0	100	13	91
5750	0	70	15	86
6000	0	39	21	87

TABLE 5. Average coefficient of determination (r^2) values and average RMSVD values for comparison between the wind profiler and VAD (unmodified) data sets.

Season	Avg (r^2) u-component	Avg (r^2) v-component	Avg RMSVD (kts)
Fall	0.272	0.230	7.872
Winter	0.485	0.492	13.104
Spring	0.371	0.046	25.174
Summer	0.156	0.285	15.748

TABLE 6. Number of matched pairs between the VAD wind (unmodifed) data and the rawinsonde wind data.

Season	Fall	Spring	Summer	Winter
Total VAD observations	2445	21582	18618	17962
Total rawinsonde	231	1518	1250	749
Height (m)				
600	0	2	6	10
900	3	16	22	8
1200	3	14	17	8
1500	0	0	2	3
1800	0	0	0	2
2100	3	17	15	6
2400	3	18	13	4
2700	3	11	11	5
3000	0	2	3	5
3300	2	8	14	2
3600	3	6	10	5
3900	0	0	0	0
4200	1	6	8	2
4500	0	0	0	0
4800	1	6	1	1
5100	0	0	0	0
5400	0	0	0	0
5700	0	0	0	0
6000	0	1	3	2

TABLE 7. Average coefficient of determination (r^2) values and average RMSVD values for comparison between the VAD wind (unmodified) and the rawinsonde data sets.

Season	Avg (r^2) u-component	Avg (r^2) v-component	Avg RMSVD (kts)
Fall	0.329	0.594	7.570
Winter	0.655	0.813	8.204
Spring	0.203	0.272	21.763
Summer	0.313	0.509	11.364

TABLE 8. Number of matched pairs between the rawinsonde and wind profiler data sets.

Season	Fall	Spring	Summer	Winter
Total rawinsonde observations	231	1518	1250	749
Total profiler observations	10723	22769	14229	14410
Height (m)				
500	1	4	1	0
750	1	4	1	0
1000	1	4	1	0
1250	1	4	1	0
1500	1	4	1	0
1750	1	4	1	0
2000	1	4	1	0
2250	1	4	1	0
2500	1	4	1	0
2750	0	4	1	0
3000	0	2	0	0
3250	1	2	1	0
3500	0	2	0	0
3750	1	4	1	0
4000	0	0	0	0
4250	0	4	1	0
4500	0	1	0	0
4750	0	4	0	0
5000	0	4	0	0
5250	0	1	0	0
5500	0	2	0	0
5750	1	4	1	0
6000	1	4	1	0

TABLE 9. Average coefficient of determination (r^2) values and average RMSVD values for comparison between the rawinsonde and wind profiler data sets.

Season	Avg (r^2) u-component	Avg (r^2) v-component	Avg RMSVD (kts)
Fall	Not computed	Not computed	2.374
Winter	No matches	No matches	No matches
Spring	0.705	0.753	13.073
Summer	Not computed	Not computed	2.619

5. Modified WSR-88D VAD wind data and wind profiler comparisons

a) Results of modified VAD wind data / wind profiler comparison

1) FALL

Since this season only had three days of data compared to two weeks of data in the other seasons, the conclusions made for this season from this data should be carefully considered due to the smaller sample size.

Table 10 shows the changes in the number of matched pairs between the wind profiler data and the VAD wind data for the fall season. A sharp increase or decrease was noticed in the number of matches between the different range values for the heights of 1250 m through 2000 m. For instance, at 1500 m, the number of matches is zero or one for most range values, except for a range value of 20 km, when the number of matches increases to 27. This type of increase or decrease occurred at these heights in all of the seasons, as will be shown later. This phenomena may be due to the WSR-88D having to use different elevation scans when the range adaptable parameter is changed.

Examining Figure 13a and 13b, along with Table 11, shows that for the fall season, changing the range adaptable parameter does not improve the (r^2) value. The default value of 30.0 km has the highest average value for (r^2) over all heights for the u-component and the v-component. However, the lowest average RMSVD value was when the range parameter was decreased to a value of 24.0 km. It is possible that if the sample size had been larger, the average values for (r^2) may have been improved at this range

value also. It should also be remembered that the inversions for this data set were of medium strength compared to the other seasons. Stronger inversions during this season might also have changed the results.

Since this thesis is concerned primarily with low-level inversions, it is necessary to examine how the (r^2) value changes for different range values at heights in the lower levels of the atmosphere. Figure 14a through 14h show changes in the (r^2) value for the u and v components at 750 m, 1000 m, 1750 m, and 2250 m respectively.

Some improvement is noted in the (r^2) value for the u-component at 1000 m, shown in Figure 14c. However, this improvement is caused by increasing the range value to 32.0 km, which contradicts other previous studies (Davis, 1995), (Lee and Ingram, 1995) that suggested decreasing the range value to improve the winds. Also, the p-value at the range value of 30.0 km for the u-component at this height, given in appendix B, is 0.002. The p-value at the range of 32.0 km for the u-component at this height, given in appendix C is 0.042. This indicates that even though the (r^2) value improved when the range value was increased to 32.0 km, the level of uncertainty associated with this (r^2) value increased, although it is still below the chosen level of significance ($\alpha = 0.05$).

Improvements in the (r^2) value for the v-component are made at 750 m, 1000 m, and 2250 m as shown in Figure 14b, 14d, and 14h. These graphs show decreasing the range value to 28.0 km or 26.0 km would improve the v-component of the wind at all of these heights. The p-values associated with these heights all show a decrease when the range

value is decreased, indicating that the uncertainty associated with the (r^2) value is also decreased.

For each season for the comparison between the wind profiler and the VAD wind data, appendix E lists the (r^2) values of the u and v components for all of the different range values at all heights.

Therefore, a conclusion can be made from this data that for the fall season, decreasing the range adaptable parameter from the default value of 30.0 km to a value of 28.0 km or 26.0 km would not help improve the overall average (r^2) values for the VAD wind data to agree more with the wind profiler data. However, decreasing the range value to 28.0 km or 26.0 km could improve the (r^2) values of the VAD wind data and maybe help a forecaster get a better representation of the winds just in the lower levels of the atmosphere.

2) WINTER

In the original comparison, the winter season had the highest average (r^2) value. This was due to the weaker inversions during this time of year. The data in Table 13, along with Figures 15a and 15b, shows that the average (r^2) values over all heights examined for the u and v components can be improved if the range adaptable parameter value is decreased to 22.0 km. Also, the lowest RMSVD value occurs when the range value is decreased to 20.0 km. Table 12 shows the changes in the number of matched pairs between the wind profiler data and the VAD wind data for the winter season. A sharp

increase or decrease was again noticed in the number of matched pairs between the different range values for heights 1250 m through 2000 m.

Examining how the (r^2) value changes for different range values at specific heights in the lower atmosphere, a closer look at Figure 15a and 15b shows that decreasing the range value to 22.0 km does not necessarily improve the (r^2) value at the lower height levels. Figure 16a through 16h reflect this by showing how the (r^2) value changes for the u and v components at 750 m, 1250 m, 1500 m , and 1750 m respectively.

Improvements in the (r^2) value for the u-component are made at each of these heights. Figure 16a shows that at 750 m, any range value improves the (r^2) value compared to the default value. A marked improvement in the (r^2) value was also made at 1250 m when the range value was set to either 22.0 km or 20.0 km, as shown in Figure 16c. Figure 16e shows that at 1500 m, the (r^2) value was highest when the range value was at 22.0 km. All of the range values less than 30.0 km at 1750 m improved the (r^2) value, as shown in Figure 16g. The p-values for each of these heights at the different range values were all approximately zero, the same as the default range value, indicating a high level of certainty in the (r^2) values.

Improvement in the (r^2) value for the v-component was only made at 1750 m when the range value was decreased to 28.0 km, as shown in Figure 16h. The p-values for the different range values, 30.0 km and 28.0 km, at this height were both approximately zero, indicating a high level of certainty in the (r^2) values.

Therefore, for the winter season, a conclusion can be made that decreasing the range value to 22.0 km or 20.0 km would help the overall VAD winds agree more with the wind profiler data, but a forecaster should be aware that changing the range value does not necessarily result in improvement of the VAD winds at all levels of the atmosphere. There is not a single range value that will clearly improve the VAD wind data at all levels. The data in this research also shows that by changing the range adaptable parameter, only the u-component of the winds in the lower levels of the atmosphere would be improved, and that the v-component of the winds would be made worse. Although this is what the data suggests, this is probably not a physical representation of what is occurring. The differences in the u and v components in this comparison and the other comparisons in this research are probably due to the relationship between the radar beam, the prevailing wind direction and the topography surrounding Vandenberg AFB. There is a mountain range oriented northwest to southeast located east of Vandenberg that might be affecting the calculations of the u and v components of the wind depending on the wind direction.

3) SPRING

Table 14 shows the changes in the number of matched pairs between the wind profiler data and the VAD wind data for the spring season. Once again, there is a sharp increase or decrease in the number of matched pairs between the different range values at heights 1250 m through 2000 m.

Table 15, along with Figure 17a and 17b, shows that decreasing the range value best improves the average (r^2) value for the v-component at 28.0 km. For the u-component,

the default value of 30.0 km still has the highest average (r^2) value. The best average RMSVD value occurs when the range value is increased to 32.0 km.

Figure 18a through 18h examines how the (r^2) value changes for the different range values for the lower levels of the atmosphere at 1000 m, 1250 m, 1500 m and 1750 m respectively.

The (r^2) value for the u-component improves for heights of 1250 m and 1500 m when the range value is decreased to 22.0 km as shown in Figure 18c and 18e. The p-values for 22.0 km and the default value of 30 km at these heights are all approximately zero, indicating a high level of certainty for the (r^2) values.

The (r^2) values for the v-component are systematically very low for this season. As mentioned earlier, this may have to do with the radar beam, the prevailing wind direction, and the topography surrounding Vandenberg. The only significant improvement in the (r^2) value for the v-component is made at 1750 m when the range value is decreased to 28.0 km, as shown in Figure 18h. The p-value associated with this height for the different range values goes from 0.037 at 30.0 km to approximately zero at 28.0 km, indicating a higher level of certainty with the (r^2) value at 28.0 km.

Therefore, for the spring season, the same conclusion can be made that changes in the range adaptable parameter does not necessarily result in improvement in the VAD winds for all levels. The data suggests that decreasing the range value to 28.0 km or 22.0 km can help one component of the VAD wind agree more with the wind profiler, but not necessarily the other component. As mentioned earlier, this improvement in just one

component of the wind may not be real due to the reasons mentioned before. Decreasing the range value to 28.0 km is probably the best value to use since the average (r^2) value for all heights examined is highest at this range value.

4) SUMMER

Table 16 shows the changes in the number of matched pairs between the wind profiler data and the VAD wind data for the summer season. The sharp increase or decrease in the number of matched pairs is again evident between the different range values at heights 1250 m through 2000 m.

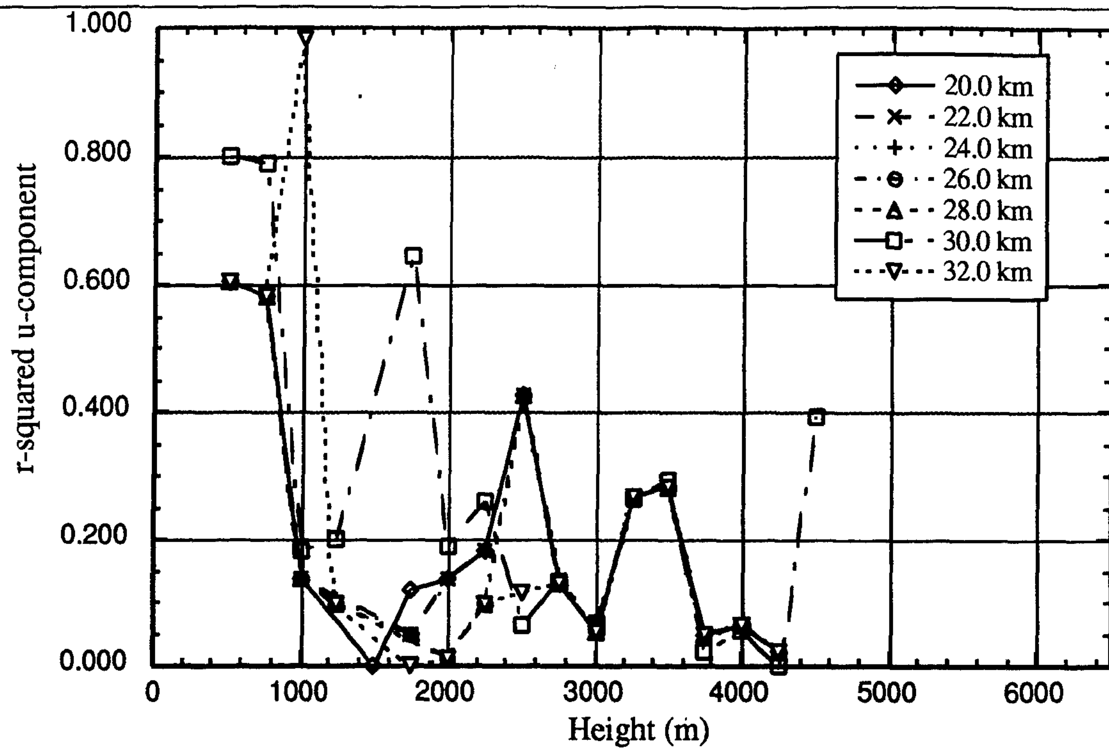
The overall average (r^2) for the u and v components both showed the best improvement when the range value was decreased to 28.0 km. The (r^2) value also showed some improvement if the range was decreased to a value between 26.0 km and 22.0 km. The overall average RMSVD value improved the most when the range was decreased to 24.0 km.

Figure 20a through 20f examines how the (r^2) value changes for the different range values at lower heights in the atmosphere at 1000 m, 1250 m, 1500 m, and 1750 m respectively. The (r^2) value for the u-component shows improvement when the range value is decreased to 22.0 km at heights of 1250 m and 1500 m, shown in Figure 20c and 20e. The p-values for the range values at these heights were both approximately zero, indicating a high level of certainty. An improvement in the (r^2) value also occurred when the range value was decreased to 28.0 km at 1750 m, shown in Figure 20g. In this case,

the p-value went from 0.304 for a range value of 30.0 km to a value of 0.002 for a range value of 28.0 km, thus improving the level of certainty along with the (r^2) value.

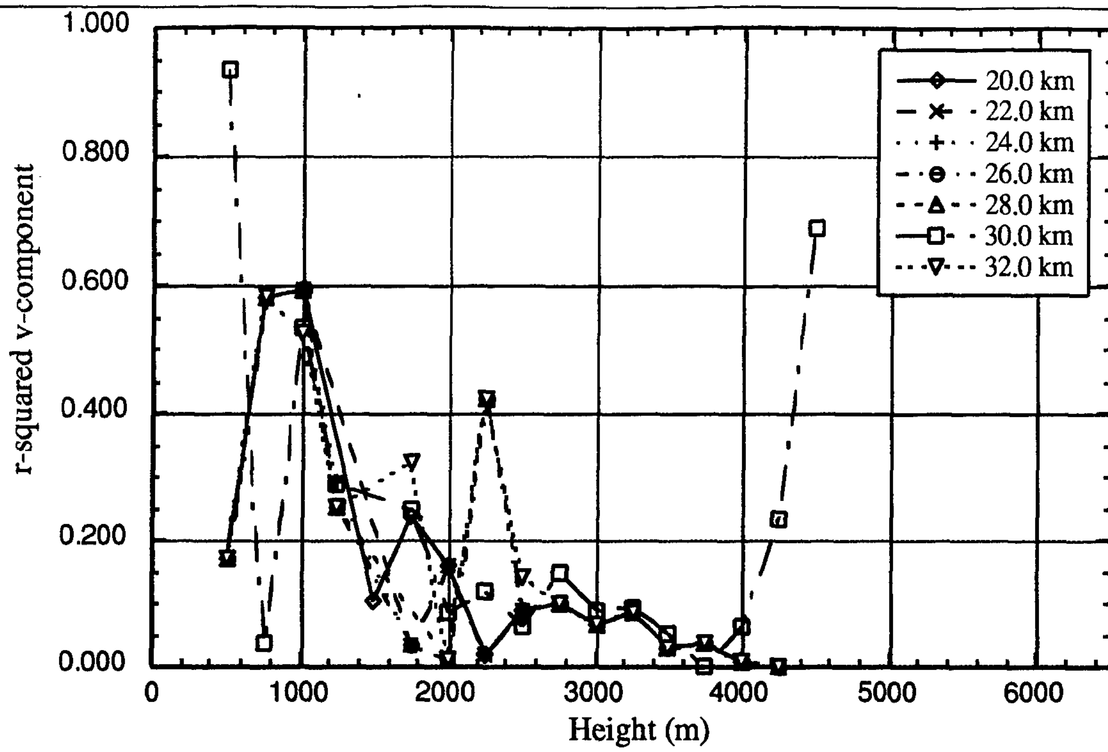
The (r^2) value for the v-component showed improvement when the range value was decreased to 22.0 km at a height of 1250 m, as shown in Figure 20d. The (r^2) value for the v-component also improved when the range value was decreased to 28.0 km or 20.0 km at a height of 1750 m, as shown in Figure 20h. The p-values for all of these range values at these heights were all approximately zero, indicating a high level of certainty.

Therefore, for this season when the inversions are strongest, a conclusion can be made that the overall VAD winds can be improved to agree more with the wind profiler data by decreasing the range value to 28.0 km. Furthermore, improvement of the winds at the lower levels of the atmosphere can be made by decreasing the range value to 22.0 km.



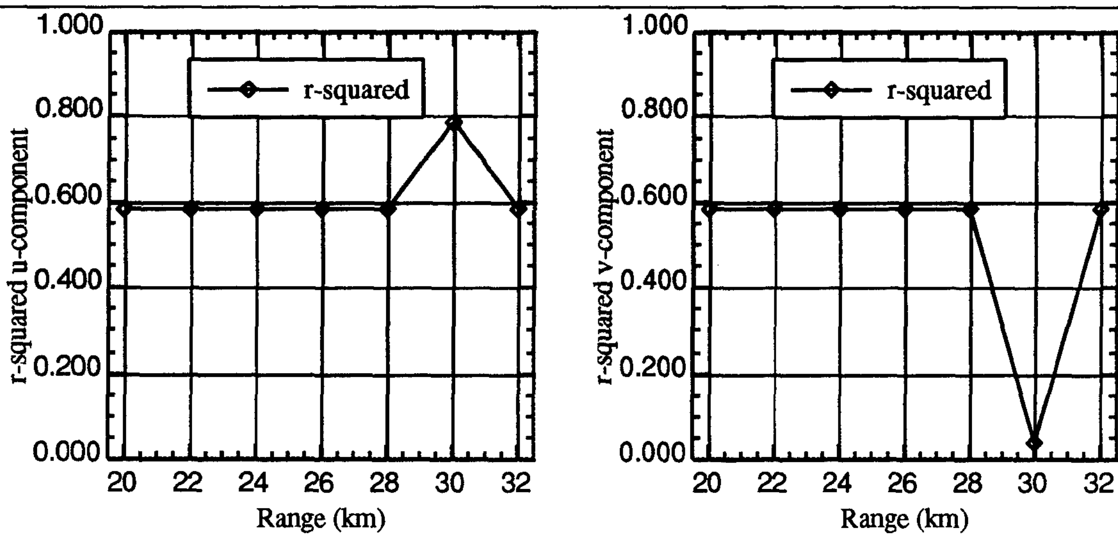
1.000
0.800
0.600
0.400
0.200
0.000
r-squared u-component
0
1000
2000
3000
4000
5000
6000
Height (m)
20.0 km
22.0 km
24.0 km
26.0 km
28.0 km
30.0 km
32.0 km

(a)



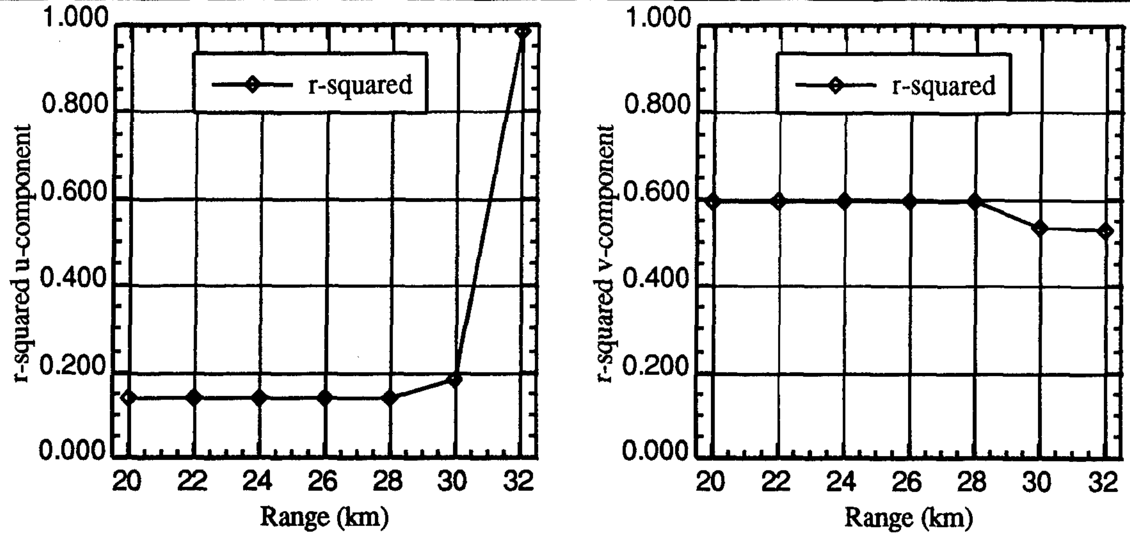
(b)

FIG. 13. Coefficient of determination (r^2) with height between the wind profiler and VAD (modified) wind data for the fall season at Vandenberg: (a) u-component; (b) v-component. Note: Some heights will not have a plot if (r^2) could not be computed due to zero, one, or two matches.

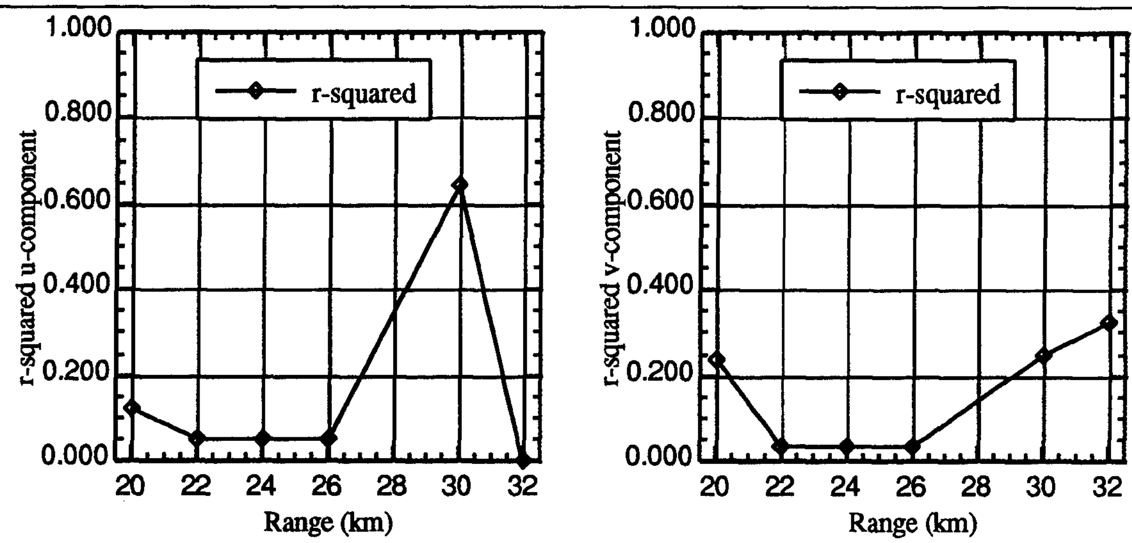


(a)

(b)


1.000
0.800
0.600
0.400
0.200
0.000
r-squared
r-squared u-component
20 22 24 26 28 30 32
Range (km)
r-squared v-component
Range (km)

(c) (d)


1.000
0.800
0.600
0.400
0.200
0.000
r-squared
r-squared u-component
20 22 24 26 28 30 32
Range (km)
r-squared v-component
Range (km)

(e) (f)

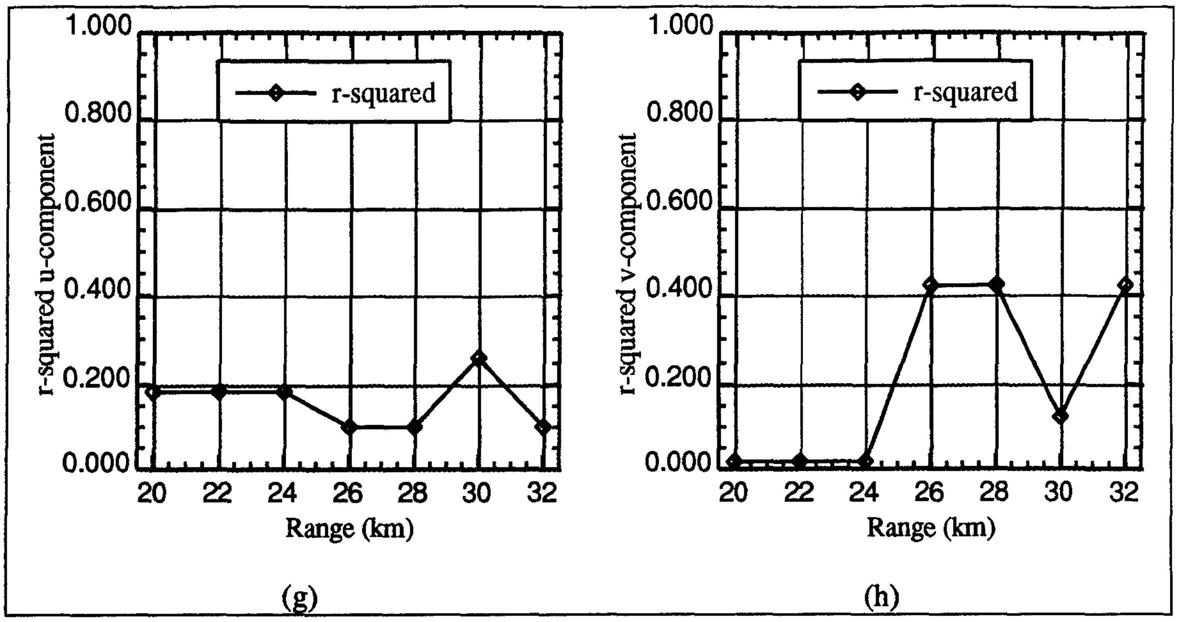
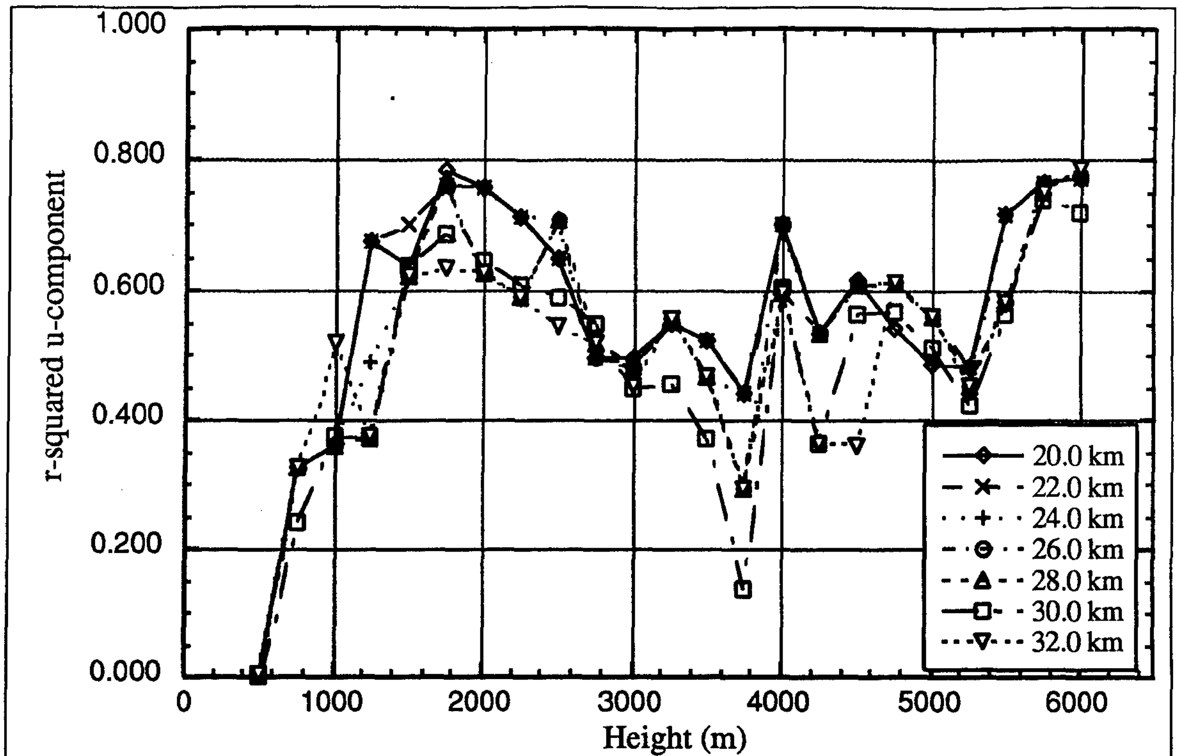
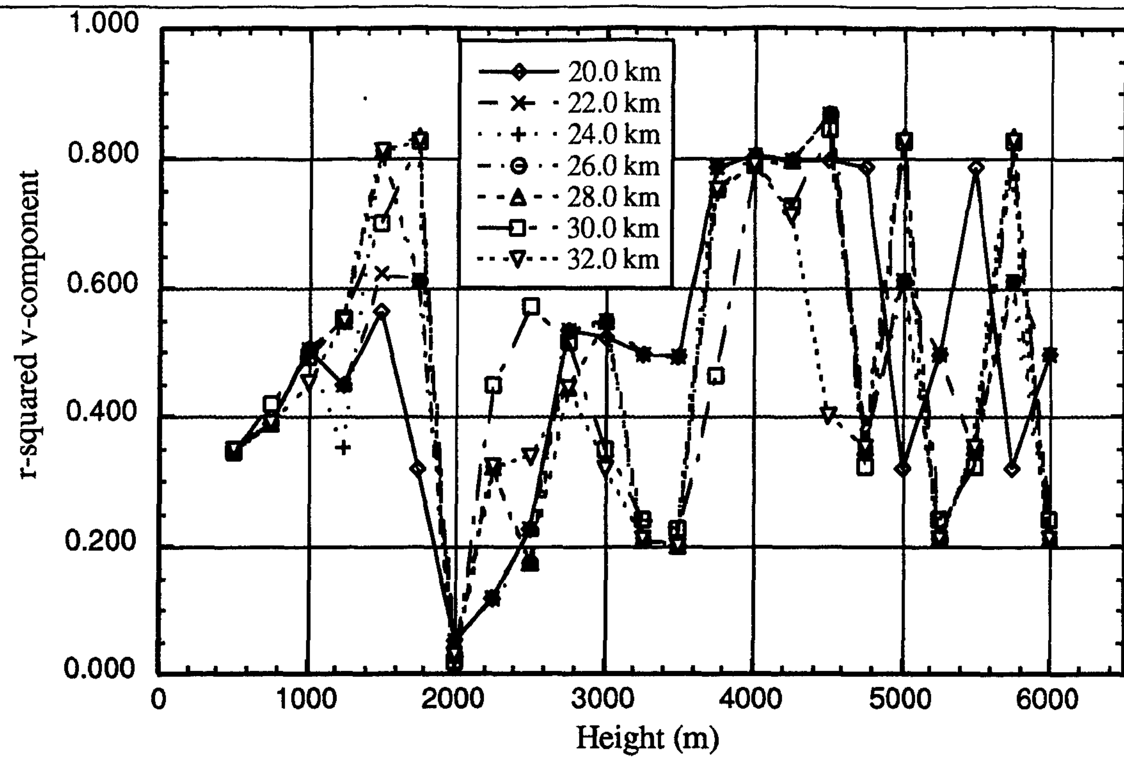


FIG. 14. Coefficient of determination (r^2) values for specific low-level heights from modified values of the range adaptable parameter in the fall season: (a) 750 m u-component; (b) 750 m v-component; (c) 1000 m u-component; (d) 1000 m v-component; (e) 1750 m u-component; (f) 1750 m v-component; (g) 2250 u-component; (h) 2250 v-component.

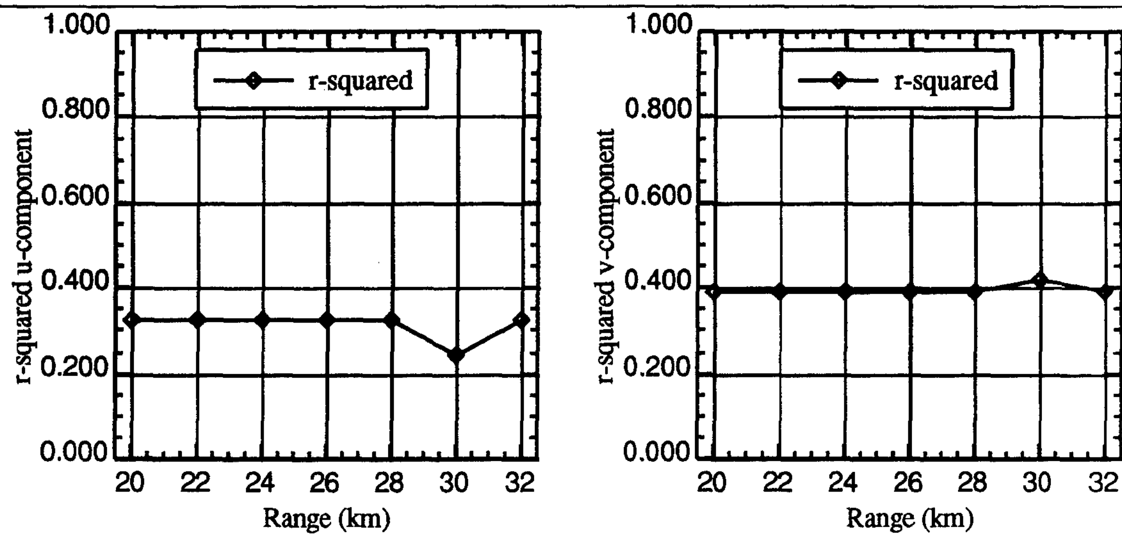

1.000
0.800
0.600
0.400
0.200
0.000
r-squared u-component
0
1000
2000
3000
4000
5000
6000
Height (m)
20.0 km
22.0 km
24.0 km
26.0 km
28.0 km
30.0 km
32.0 km

(a)

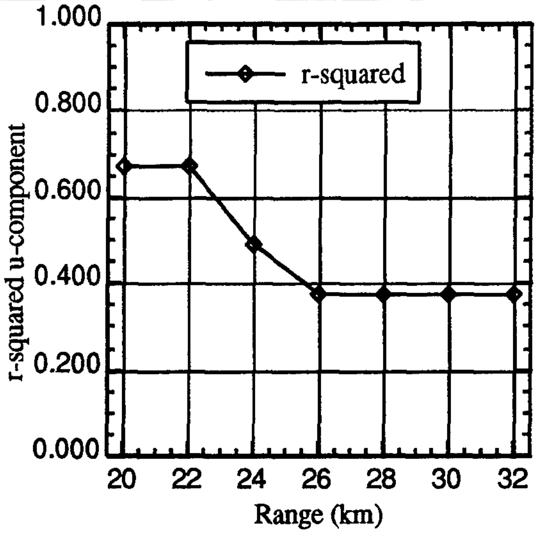


(b)

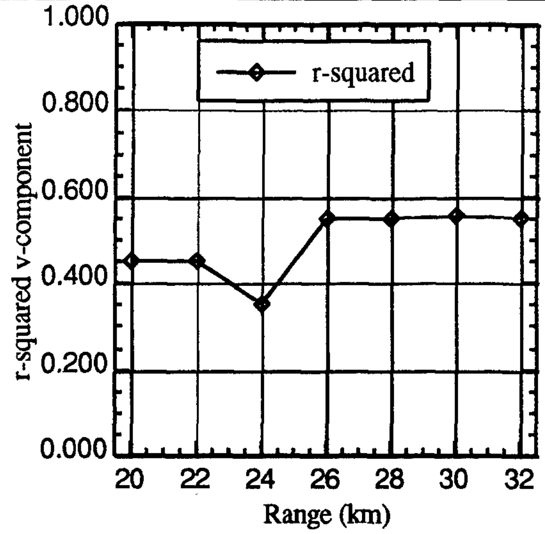
FIG. 15. Coefficient of determination (r^2) with height between the wind profiler and VAD (modified) wind data for the winter season at Vandenberg: (a) u-component; (b) v-component. Note: Some heights will not have a plot if (r^2) could not be computed due to zero, one, or two matches.



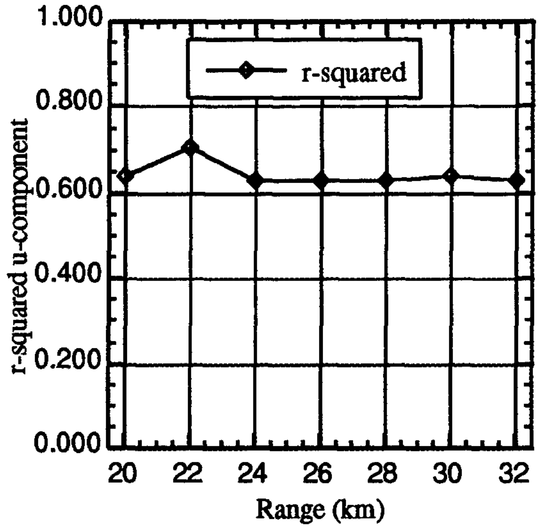
(a) (b)


r-squared
r-squared u-component
1.000
0.800
0.600
0.400
0.200
0.000
20 22 24 26 28 30 32
Range (km)

(c)


r-squared
r-squared v-component
1.000
0.800
0.600
0.400
0.200
0.000
20 22 24 26 28 30 32
Range (km)

(d)


r-squared
r-squared u-component
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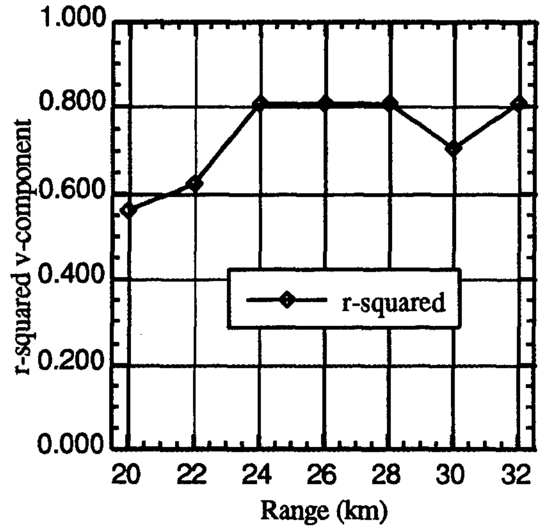
0.800
0.600
0.400
0.200
0.000
20 22 24 26 28 30 32
Range (km)

(e)


r-squared
r-squared v-component
1.000
0.800
0.600
0.400
0.200
0.000
20 22 24 26 28 30 32
Range (km)

(f)

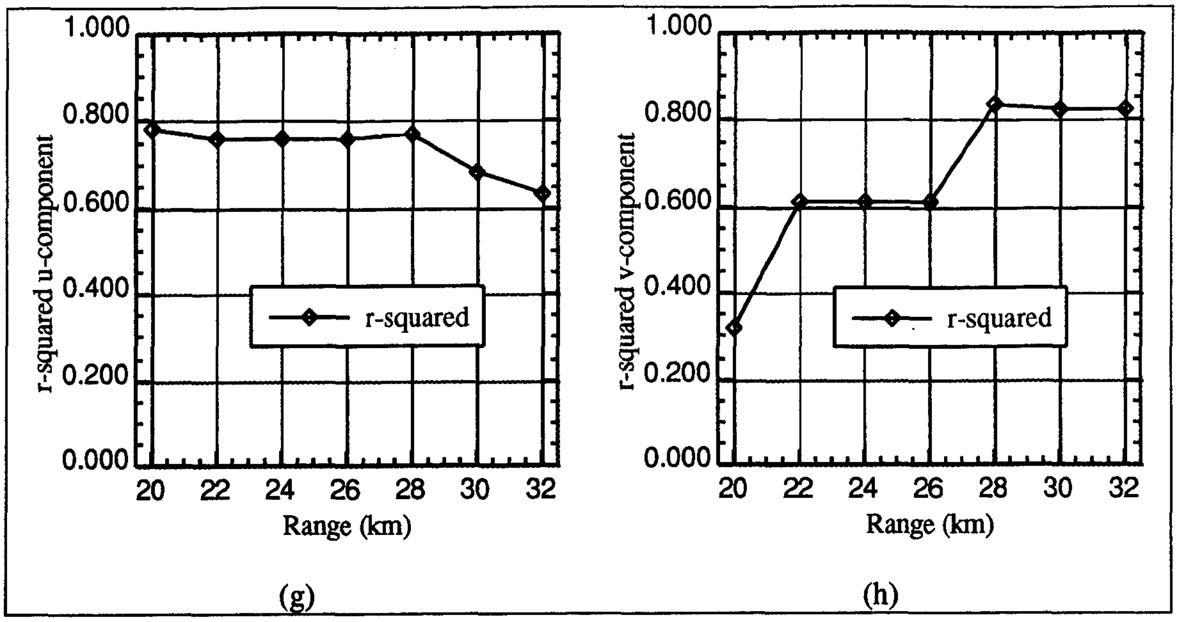
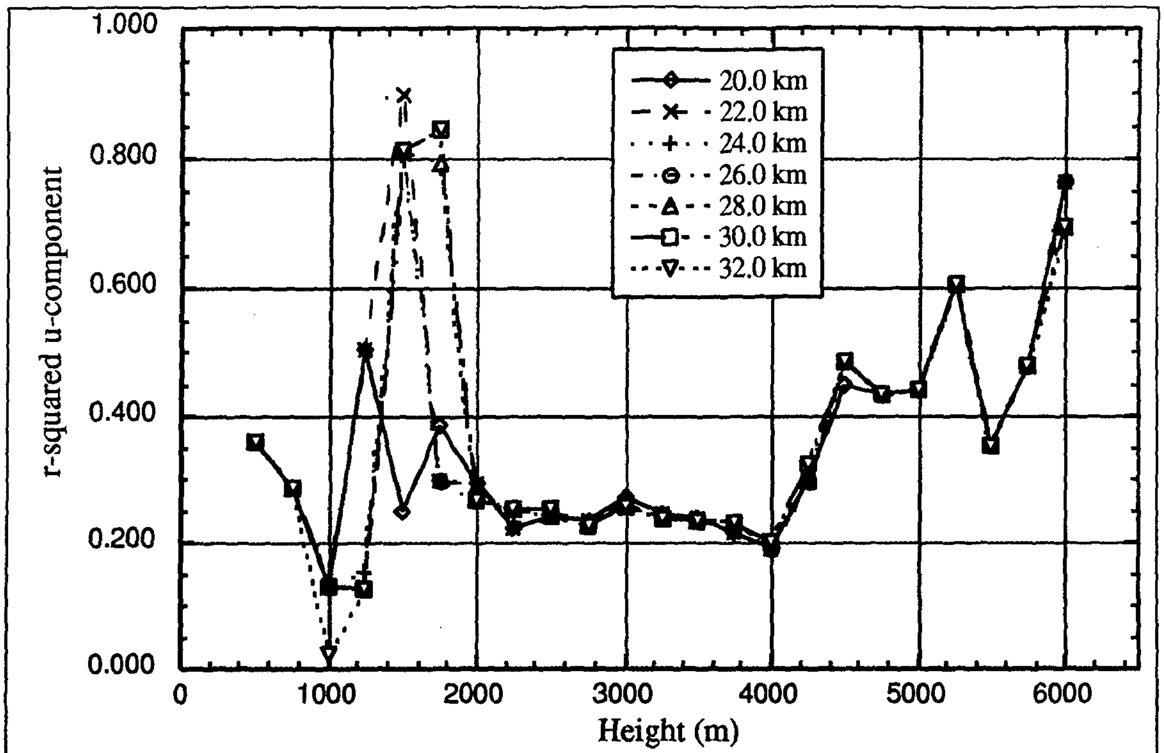
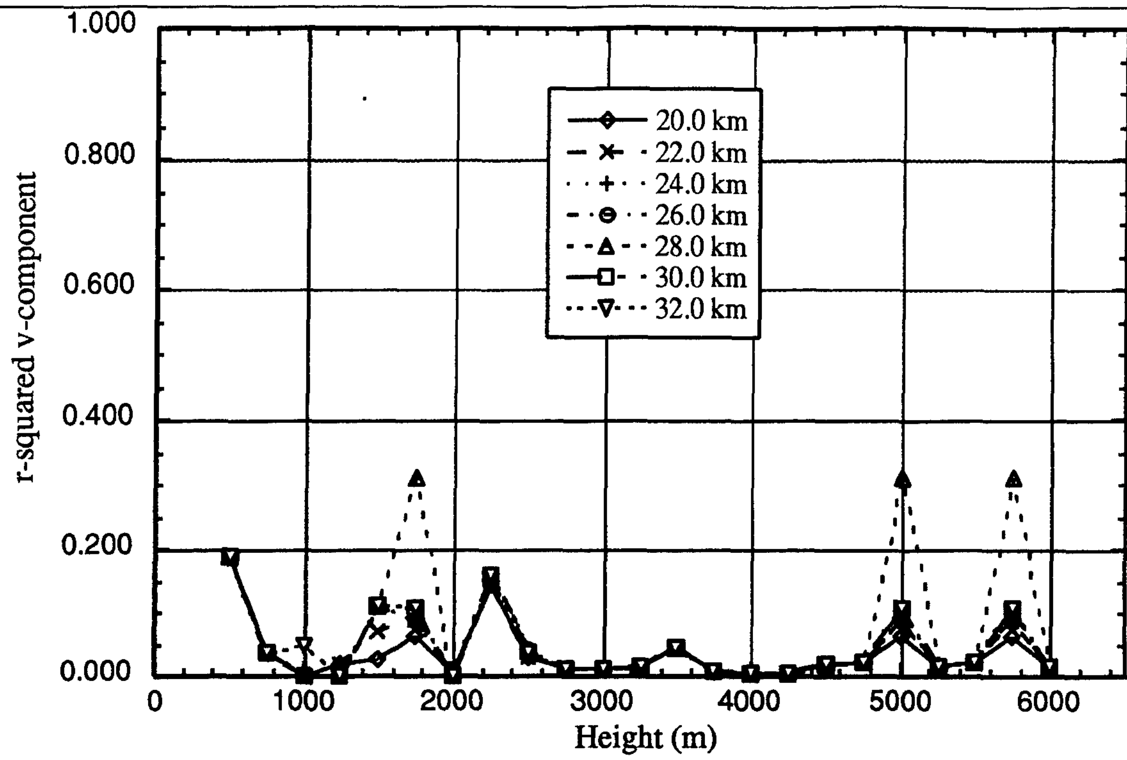


FIG. 16. Coefficient of determination (r^2) values for specific low-level heights from modified values of the range adaptable parameter in the winter season: (a) 750 m u-component; (b) 750 m v-component; (c) 1250 m u-component; (d) 1250 m v-component; (e) 1500 m u-component; (f) 1500 m v-component; (g) 1750 u-component; (h) 1750 v-component.



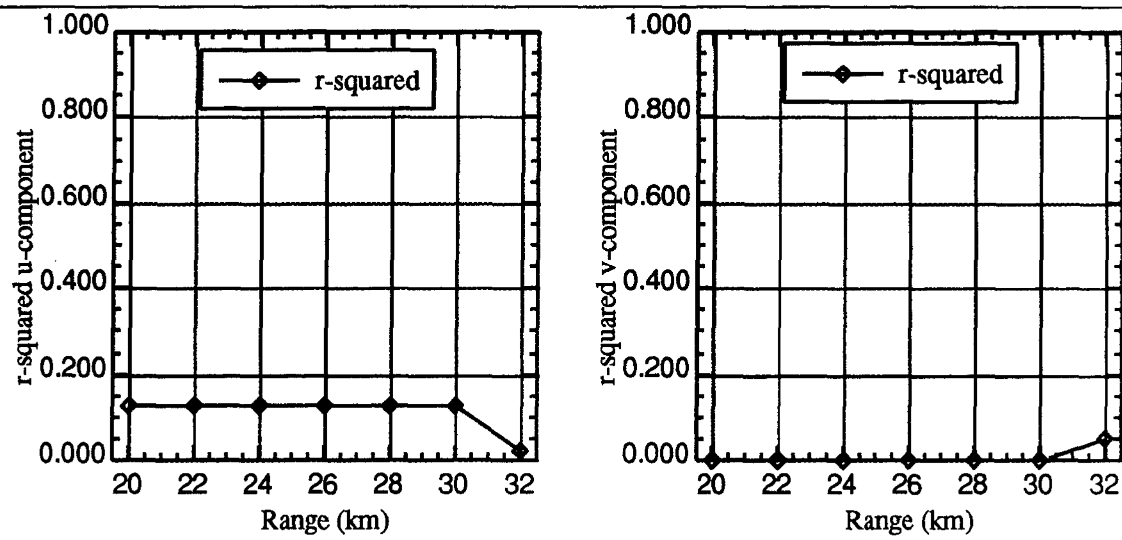
1.000
0.800
0.600
0.400
0.200
0.000
r-squared u-component
0
1000
2000
3000
4000
5000
6000
Height (m)
20.0 km
22.0 km
24.0 km
26.0 km
28.0 km
30.0 km
32.0 km

(a)

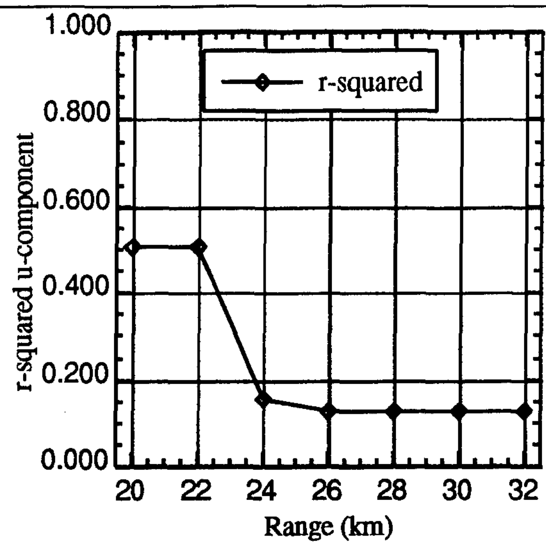


(b)

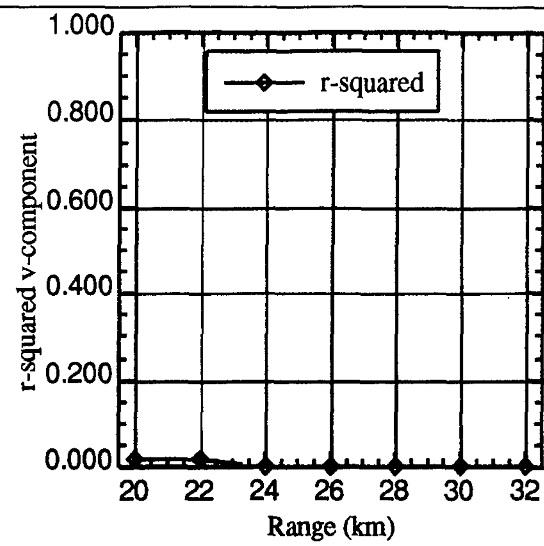
FIG. 17. Coefficient of determination (r^2) with height between the wind profiler and VAD (modified) wind data for the spring season at Vandenberg: (a) u-component; (b) v-component. Note: Some heights will not have a plot if (r^2) could not be computed due to zero, one, or two matches.



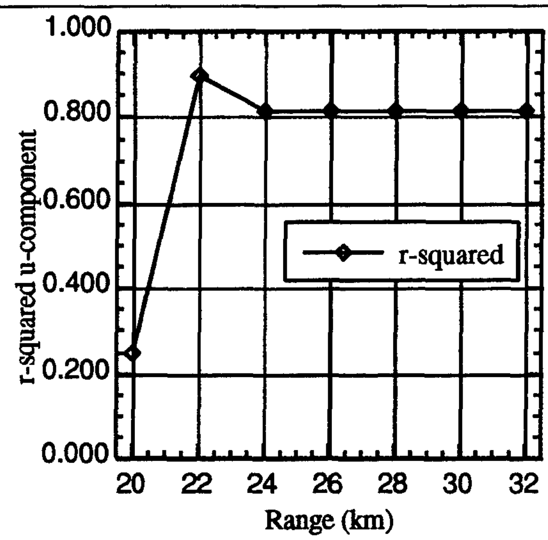
(a) (b)


r-squared
r-squared u-component
1.000
0.800
0.600
0.400
0.200
0.000
20
22
24
26
28
30
32
Range (km)

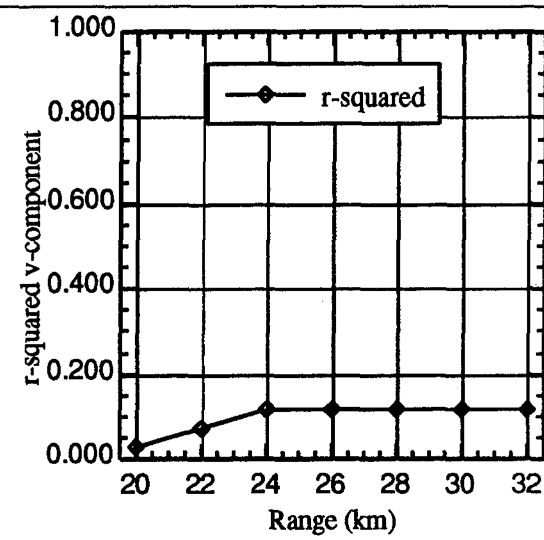
(c)


r-squared
r-squared v-component
1.000
0.800
0.600
0.400
0.200
0.000
20
22
24
26
28
30
32
Range (km)

(d)


r-squared
r-squared u-component
1.000
0.800
0.600
0.400
0.200
0.000
20
22
24
26
28
30
32
Range (km)

(e)


r-squared
r-squared v-component
1.000
0.800
0.600
0.400
0.200
0.000
20
22
24
26
28
30
32
Range (km)

(f)

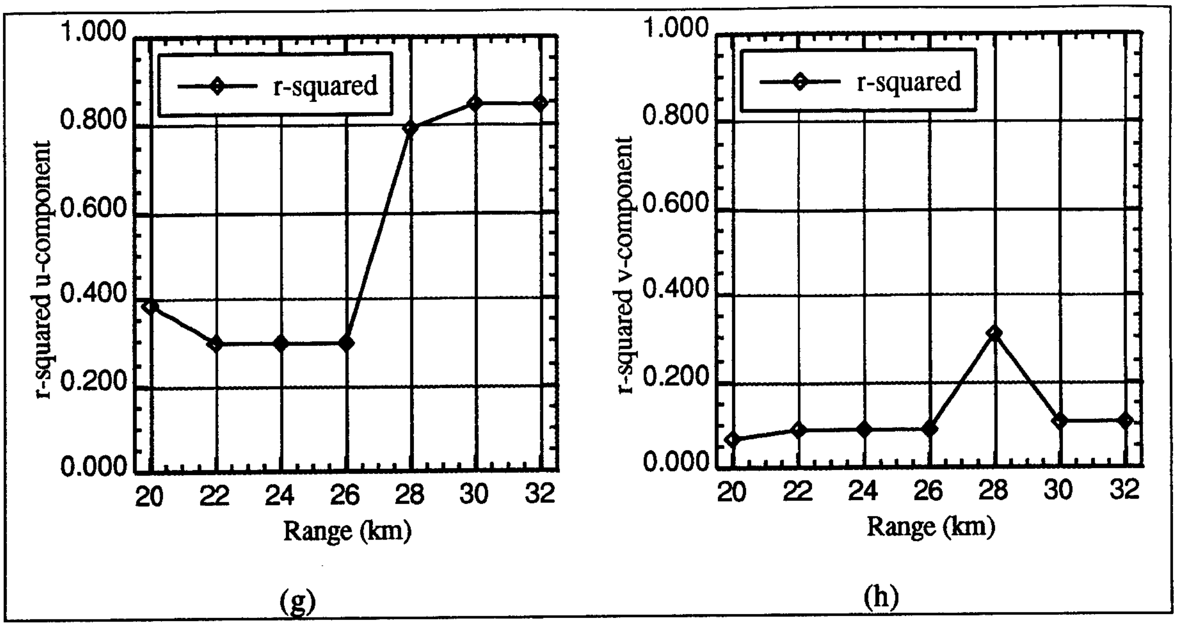
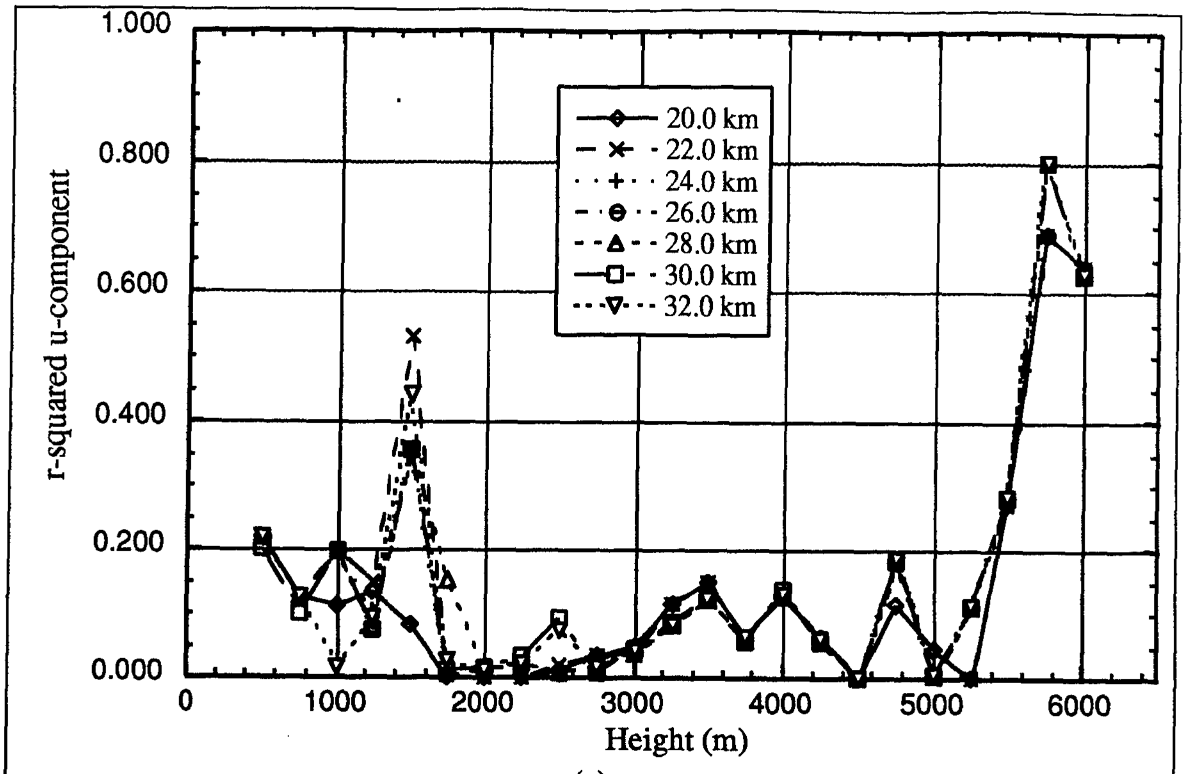
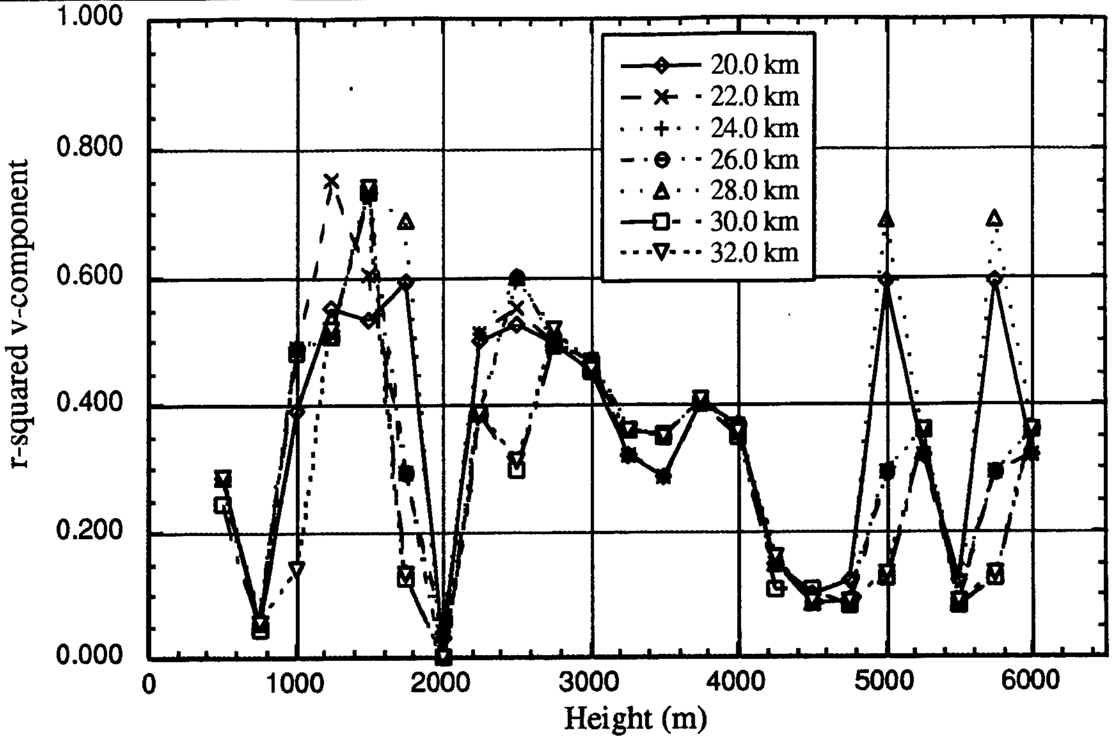


FIG. 18. Coefficient of determination (r^2) values for specific low-level heights from modified values of the range adaptable parameter in the spring season: (a) 1000 m u-component; (b) 1000 m v-component; (c) 1250 m u-component; (d) 1250 m v-component; (e) 1500 m u-component; (f) 1500 m v-component; (g) 1750 u-component; (h) 1750 v-component.

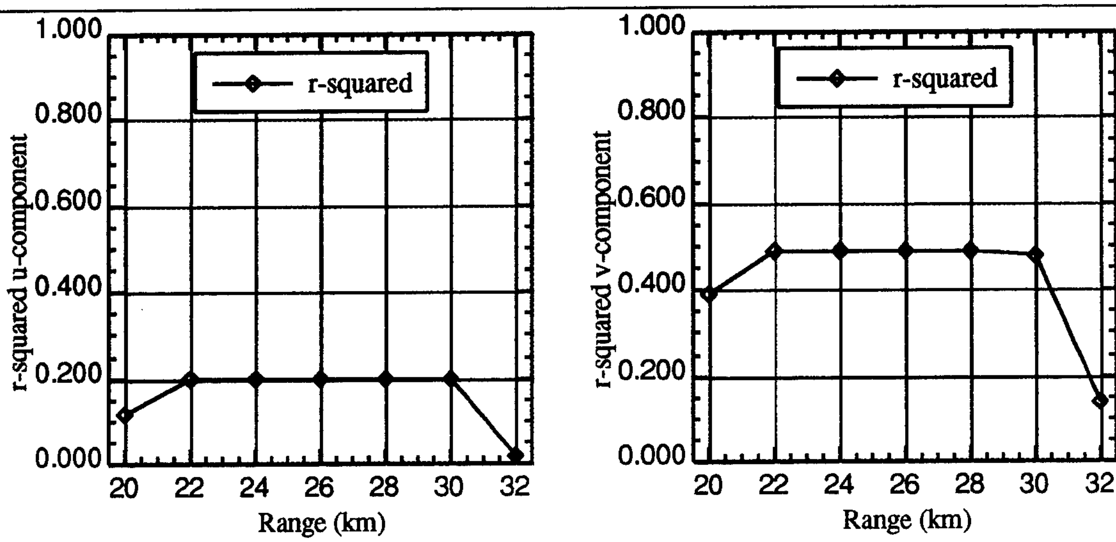

1.000
0.800
0.600
0.400
0.200
0.000
r-squared u-component
0
1000
2000
3000
4000
5000
6000
Height (m)
20.0 km
22.0 km
24.0 km
26.0 km
28.0 km
30.0 km
32.0 km

(a)

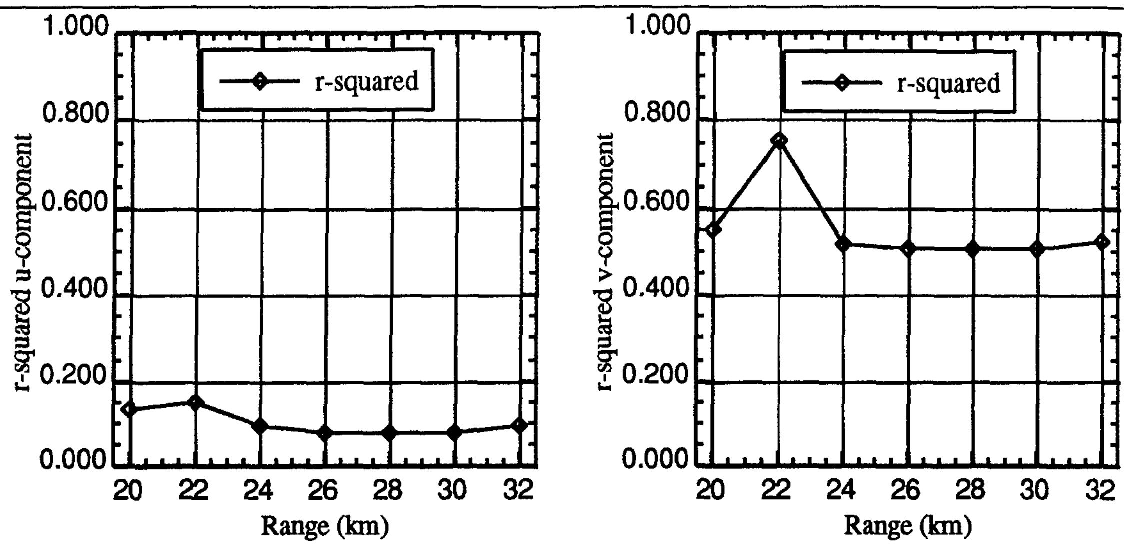


(b)

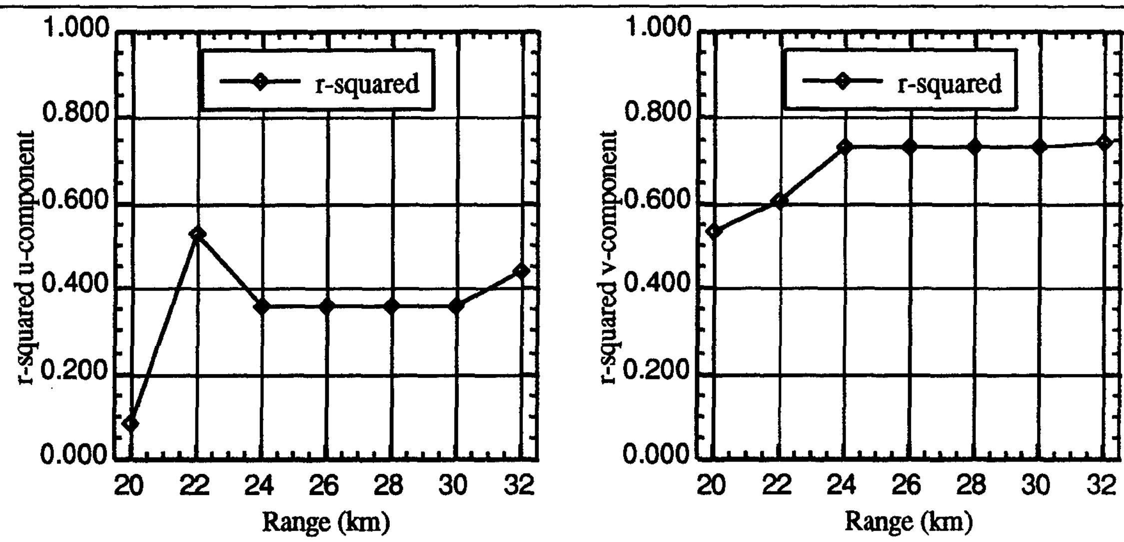
FIG. 19. Coefficient of determination (r^2) with height between the wind profiler and VAD (modified) wind data for the summer season at Vandenberg: (a) u-component; (b) v-component. <u>Note:</u> Some heights will not have a plot if (r^2) could not be computed due to zero, one, or two matches.



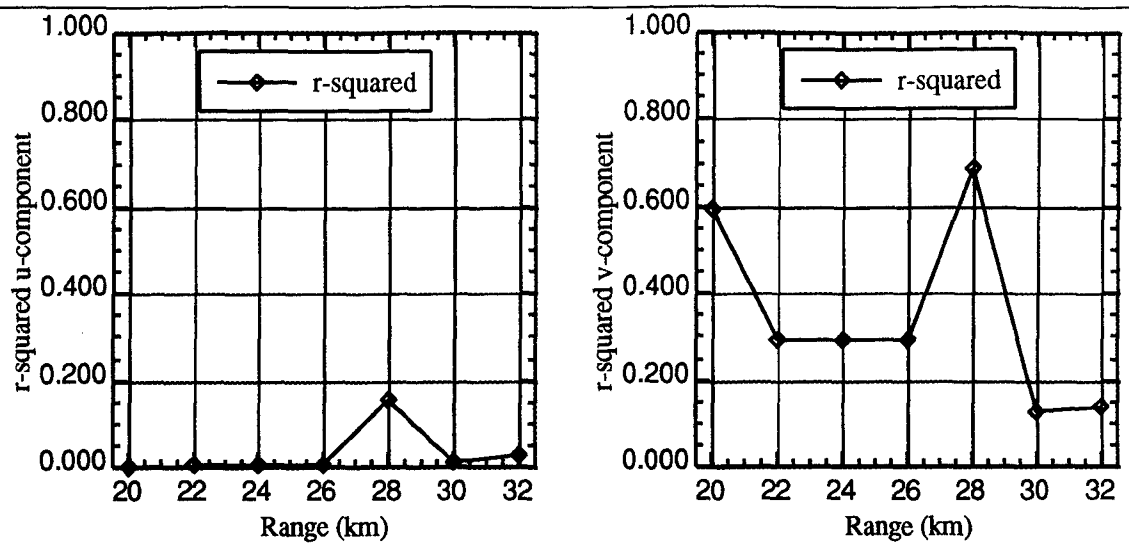
(a) (b)


r-squared
r-squared u-component
Range (km)
r-squared
r-squared v-component
Range (km)

(c) (d)


r-squared
r-squared u-component
Range (km)
r-squared
r-squared v-component
Range (km)

(e) (f)



(g) (h)

FIG. 20. Coefficient of determination (r^2) values for specific low-level heights from modified values of the range adaptable parameter in the summer season: (a) 1000 m u-component; (b) 1000 m v-component; (c) 1250 m u-component; (d) 1250 m v-component; (e) 1500 m u-component; (f) 1500 m v-component; (g) 1750 u-component; (h) 1750 v-component.

TABLE 10. Number of matched pairs between the wind profiler and VAD wind (modified) data in the fall season modifying the range adaptable parameter.

Range Value (km)	32.0	30.0 (Default)	28.0	26.0	24.0	22.0	20.0
Height (m)							
500	5	4	5	5	5	5	5
750	5	4	5	5	5	5	5
1000	3	43	42	42	42	42	42
1250	38	37	38	38	36	0	0
1500	1	1	1	1	1	0	27
1750	3	3	0	30	30	30	24
2000	18	24	18	18	27	27	27
2250	18	24	18	18	27	27	27
2500	18	22	30	30	30	30	30
2750	31	31	31	31	31	31	31
3000	30	34	30	30	30	30	30
3250	20	22	20	20	20	20	20
3500	20	22	20	20	20	20	20
3750	29	38	29	29	29	29	29
4000	20	23	20	20	20	20	20
4250	27	11	27	27	27	27	27
4500	1	6	1	1	1	1	1
4750	0	0	0	0	0	0	0
5000	0	0	0	0	0	0	0
5250	0	0	0	0	0	0	0
5500	0	0	0	0	0	0	0
5750	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0

TABLE 11. Average coefficient of determination (r^2) values and average RMSVD values for comparison between the wind profiler and VAD wind (modified) data sets for the fall season, modifying the range adaptable parameter.

Range Value	Avg (r^2) u-component	Avg (r^2) v-component	Avg RMSVD (kts)
32.0	0.224	0.184	7.607
30.0 (Default)	0.272	0.230	7.872
28.0	0.202	0.175	7.430
26.0	0.191	0.166	7.649
24.0	0.206	0.151	7.294
22.0	0.213	0.141	7.470
20.0	0.203	0.152	7.703

TABLE 12. Number of matched pairs between the wind profiler and VAD wind (modified) data in the winter season modifying the range adaptable parameter.

Range Value (km)	32.0	30.0 (Default)	28.0	26.0	24.0	22.0	20.0
Height (m)							
500	259	252	259	259	259	259	259
750	262	257	262	262	262	262	262
1000	163	267	288	288	288	288	288
1250	210	189	210	210	210	150	150
1500	140	144	140	140	140	156	230
1750	121	127	126	200	200	200	164
2000	179	191	179	179	154	154	154
2250	175	187	175	175	152	152	152
2500	156	166	135	135	135	137	137
2750	115	122	115	128	128	128	128
3000	108	110	121	121	121	121	123
3250	97	102	97	97	97	93	93
3500	97	102	97	97	97	93	93
3750	94	108	94	94	96	96	96
4000	91	87	91	88	88	88	88
4250	89	90	86	86	86	86	86
4500	90	81	84	84	84	84	87
4750	84	80	84	84	84	84	89
5000	84	80	84	84	84	84	89
5250	94	93	94	94	94	87	87
5500	95	91	95	95	102	102	102
5750	97	86	97	104	104	104	104
6000	95	87	95	107	107	107	107

TABLE 13. Average coefficient of determination (r^2) values and average RMSVD values for comparison between the wind profiler and VAD wind (modified) data sets for the winter season, modifying the range adaptable parameter.

Range Value	Avg (r^2) u-component	Avg (r^2) v-component	Avg RMSVD (kts)
32.0	0.504	0.464	13.049
30.0 (Default)	0.485	0.492	13.104
28.0	0.529	0.494	12.606
26.0	0.533	0.470	12.710
24.0	0.561	0.455	12.967
22.0	0.573	0.503	12.686
20.0	0.566	0.496	12.337

TABLE 14. Number of matched pairs between the wind profiler and VAD wind (modified) data in the spring season modifying the range adaptable parameter.

Range Value (km)	32.0	30.0 (Default)	28.0	26.0	24.0	22.0	20.0
Height (m)							
500	70	70	70	70	70	70	70
750	70	70	70	70	70	70	70
1000	28	380	380	380	380	380	380
1250	344	344	344	344	354	51	51
1500	36	36	36	36	36	47	419
1750	31	31	39	390	390	390	332
2000	392	392	392	392	326	326	326
2250	393	393	393	393	327	327	327
2500	363	363	310	310	310	306	306
2750	276	276	276	278	278	278	278
3000	244	244	245	245	245	245	251
3250	216	216	216	216	216	218	218
3500	217	217	217	217	217	219	219
3750	201	201	201	201	202	202	202
4000	186	186	186	185	185	185	185
4250	201	201	202	202	202	202	202
4500	144	144	144	144	144	144	146
4750	124	124	124	124	124	124	124
5000	132	132	132	132	132	132	132
5250	91	91	91	91	91	91	91
5500	100	100	100	100	100	100	100
5750	70	70	70	70	70	70	70
6000	39	39	39	40	40	40	40

TABLE 15. Average coefficient of determination (r^2) values and average RMSVD values for comparison between the wind profiler and VAD wind (modified) data sets for the spring season, modifying the range adaptable parameter.

Range Value	Avg (r^2) u-component	Avg (r^2) v-component	Avg RMSVD (kts)
32.0	0.366	0.048	25.133
30.0 (Default)	0.371	0.046	25.174
28.0	0.367	0.073	25.343
26.0	0.348	0.044	25.297
24.0	0.348	0.043	25.190
22.0	0.368	0.042	25.154
20.0	0.342	0.036	25.134

TABLE 16. Number of matched pairs between the wind profiler and VAD wind (modified) data in the summer season modifying the range adaptable parameter.

Range Value (km)	32.0	30.0 (Default)	28.0	26.0	24.0	22.0	20.0
Height (m)							
500	96	106	96	96	96	96	96
750	96	106	96	96	96	96	96
1000	53	353	341	341	341	341	319
1250	290	309	293	293	302	66	73
1500	37	35	35	35	35	43	268
1750	28	29	28	267	267	267	242
2000	254	254	254	254	231	231	232
2250	254	254	254	254	231	231	232
2500	229	225	228	228	228	233	234
2750	214	217	214	214	214	214	214
3000	200	203	199	199	199	199	202
3250	182	189	182	182	182	184	184
3500	179	187	179	179	179	181	181
3750	170	169	170	170	171	171	171
4000	144	140	144	142	142	142	142
4250	146	141	146	146	146	146	146
4500	89	87	87	87	87	87	89
4750	37	36	37	37	37	37	36
5000	41	40	41	41	41	41	40
5250	12	12	12	12	12	15	15
5500	13	13	13	13	17	17	17
5750	15	15	15	19	19	19	19
6000	21	21	21	22	22	22	22

TABLE 17. Average coefficient of determination (r^2) values and average RMSVD values for comparison between the wind profiler and VAD wind (modified) data sets for the summer season, modifying the range adaptable parameter.

Range Value	Avg (r^2) u-component	Avg (r^2) v-component	Avg RMSVD (kts)
32.0	0.154	0.280	16.008
30.0 (Default)	0.156	0.285	15.748
28.0	0.161	0.379	15.433
26.0	0.150	0.327	15.332
24.0	0.149	0.335	14.913
22.0	0.157	0.329	14.982
20.0	0.132	0.352	14.953

6. Modified WSR-88D VAD wind data and rawinsonde comparisons

a) Results of Modified VAD Wind Data/Rawinsonde Comparison

The sample size is extremely low for all of the seasons in comparing the VAD wind to the rawinsonde wind data since only two weeks of data were chosen for each season (the fall season only had three days). Since rawinsondes are launched only twice a day, the maximum number of samples for a season is about 28. This is probably too small a sample size to make any reliable conclusions for the comparison between the two data sets in each season.

1) FALL

For this season, as in the comparison between the wind profiler and the VAD wind data, any conclusions made from this data should be carefully considered to the extremely low sample size. Along with the low sample size, a majority of the heights had only zero, one, or two matches, which meant that the (r^2) value could not be calculated for these heights. This makes it extremely difficult to determine any improvements in the (r^2) values from changing the range parameter value.

Table 18 shows the changes in the number of matched pairs between the rawinsonde data and the VAD wind data for the fall season. Once again a sharp increase can be seen in the number of matched pairs at 1200 m, although it is not as evident due to the low sample size.

Examining Figure 21a and 21b, along with Table 19, shows that for the fall season, no conclusive results can be determined. The average (r^2) value for the u-component over all heights examined is most improved when the range value is set to 22.0 km or 20.0 km. Increasing the range value to 32.0 km improves the average (r^2) value for the v-component over all heights examined. Also, the average RMSVD value is improved the most when the range value is decreased to 22.0 km. Setting the range value to 22.0 km might be the best setting to use since it is the best for two out of the three categories; however, a larger sample size is needed to support this conclusion.

Figure 22a through 22f examines how the (r^2) value changes for different range values at the lower levels of the atmosphere at 900 m, 1200 m, and 2400 m respectively.

Decreasing the range value below 30.0 km improves the (r^2) values for both the u and v components at 900 m and 2400 m, as shown in Figure 22a, 22b, 22e, and 22f. These decreased range values all improve the (r^2) value by the same amount. However, for the u-component, the p-value for the default value, found in appendix B is 0.109 at 900 m and 0.434 at 2400 m. For the v-component, the p-value for the default value is 0.153 for 900 m, and 0.278 for 2400 m. All of these values are higher than the chosen level of significance ($\alpha = 0.05$), indicating a very high level of uncertainty with these (r^2) values. When the range value is decreased, the p-value, found in appendix D, for the u-component decreases to 0.102 at 900 m and decreases to 0.077 at 2400 m. The level of uncertainty decreases, but is still higher than the chosen level of significance. For the v-component,

the p-value decreases to 0.143 at 900 m and decreases to 0.173 at 2400 m. Once again, the level of uncertainty drops, but is still higher than the chosen level of significance.

For each season for the comparison between the VAD wind and rawinsonde wind data, appendix F lists the (r^2) values of the u and v components for all of the different range values at all heights.

Therefore, due to the extremely small sample size, a reliable conclusion cannot be made for the fall season. Decreasing the range value appears to help the overall VAD winds agree more with the rawinsonde data and also for the VAD winds in the lower levels of the atmosphere. However, the uncertainty is too high to satisfy the level of confidence for this conclusion.

2) WINTER

Table 20 shows the changes in the number of matched pairs between the VAD wind and rawinsonde wind data. Although the number of matches is greater than the fall season, the sample size is still very small. The pattern of a sharp decrease in the number of matches between the different range values can also be seen at 1200 m.

Figure 23a and 23b, along with Table 21 shows that no improvements were made to the average (r^2) value for the u and v components or to the average RMSVD value when the range parameter was modified. The default range value of 30.0 km had the highest average values.

Figure 24a through 24h examines how the (r^2) value changes for different range values at lower heights in the atmosphere at 900 m, 1200 m, 2100 m, and 2700 m respectively.

The (r^2) value for the u-component shows improvement at 1200 m, shown in Figure 24c when the range is decreased to 22.0 km or 20.0 km. The p-value for all of the range values at this height is approximately zero, indicating a high level of confidence. The (r^2) value for the u-component also shows improvement at 2700 m, when decreasing the range value to 26.0 km or less, as shown in Figure 24g. The p-value for the u-component at 2700 m is 0.127 for 30.0 km and decreases to 0.039 when the range value is decreased below 26.0 km, indicating a higher level of certainty.

Improvement in the (r^2) value for the v-component is made at every height level, as shown in Figure 24b, 24d, 24f, and 24h. However, once again, the best value to use for the VAD range adaptable parameter varies for different levels of the atmosphere. At 900 m, shown in Figure 24a, any range value below 30.0 km gives the same improvement in the (r^2) value. The p-value for all range values at this height is approximately zero, indicating a high level of certainty. Figure 24d shows the best range value to use at 1200 m for the v-component is 22.0 km or 20.0 km. The p-value for these range values, along with the default value, at this height is approximately zero, indicating a high level of certainty. For 2100 m, as shown in Figure 24f, the best range value to use for the v-component is 28.0 km or 26.0 km. The p-value for the default range value at 30.0 km is 0.004, while the p-value for the other range values decreases to 0.001, indicating a high level of certainty again. Finally, for the 2700 m v-component, the best range value to use is 26.0 km or less. However, the p-value increases from 0.003 for the default range value to 0.009 for the other range values. This is still an acceptable level of certainty.

Therefore, for the winter season, a tentative conclusion can be made based on a small sample size that decreasing the range value is not effective for the overall VAD winds, but can improve the agreement between the VAD winds and the rawinsonde data in the lower levels of the atmosphere.

3) SPRING

Table 22 shows the changes in the number of matched pairs between the rawinsonde data and the VAD wind data for the spring season. Once again the sample size is small, so any conclusions drawn from this data will have to be carefully considered. Also, note the sharp increase in the number of matches between the different range values at a height of 1500 m.

No conclusions can be made from Figure 25a and 25b for the improvement of the (r^2) values; however, Table 23 shows that the average (r^2) values for the u and v components and the average RMSVD value dramatically improve when the range parameter is increased to 32.0 km. Appendix D shows that most of the p-values for this range value are well above the level of significance ($\alpha = 0.05$), indicating a high level of uncertainty. Since this is such a big improvement, the small sample size may be affecting the quality of the data. The second best improvement to the average (r^2) values and the average RMSVD value occurs when the range value is decreased to 22.0 km. However, the p-values for this range value at most heights is also above the level of significance, indicating a high level of uncertainty.

Figure 26a through 26f shows the (r^2) values for the lower levels of the atmosphere at heights of 900 m, 1800m , and 2100 m respectively. The graphs show that changing the range value does not improve the (r^2) values at any height in the lower levels.

Therefore, a reliable conclusion about modifying the range parameter cannot be made for the spring season based on the small sample size. According to the data, the best value for the range parameter is to increase it to 32.0 km to improve the agreement between the VAD wind and the rawinsonde data. However, there is a high level of uncertainty with most of the data in this season.

4) SUMMER

Table 24 shows the changes in the number of matched pairs between the rawinsonde data and the VAD wind data for the summer season. A sharp increase in the number of matched pairs between the different range values is evident at 1500 m. The sample size is the largest compared to the other seasons, but it is still too low to make a conclusion with a level of confidence that is satisfactory.

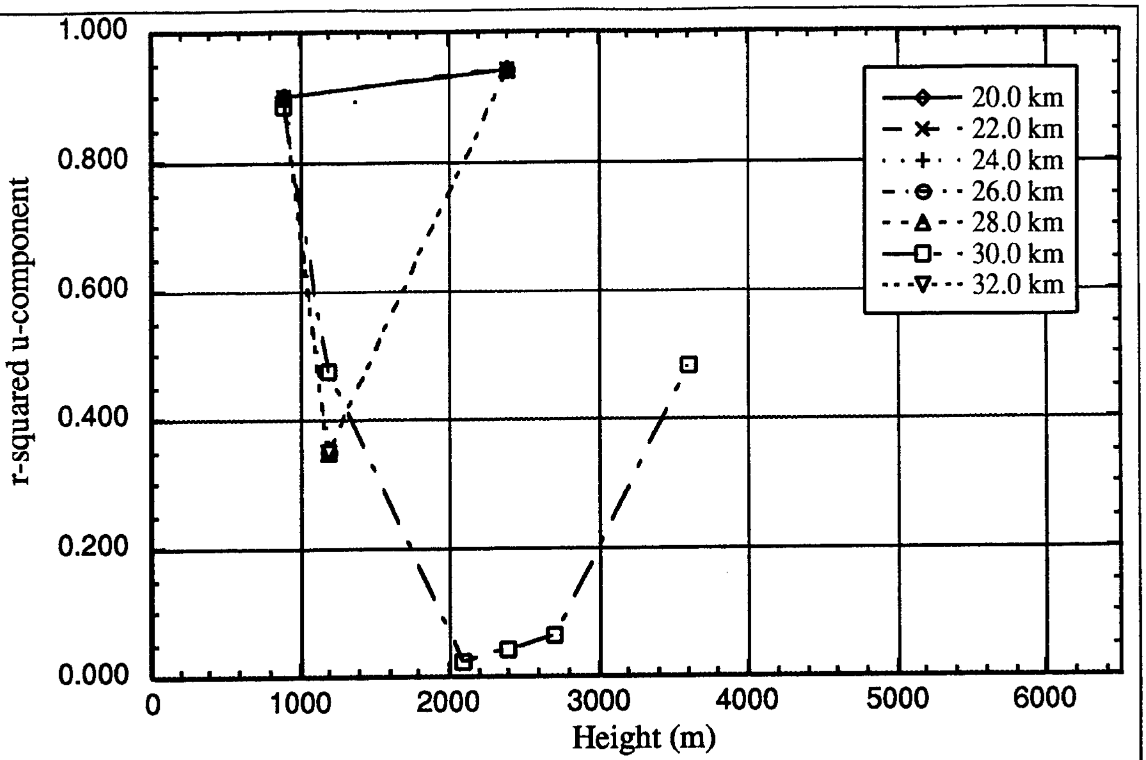
Examining Figure 27a and 27b, along with Table 25, shows conflicting data to determine the best range value. The highest average (r^2) value for the u-component occurs when the range value is set to 32.0 km. The highest average (r^2) value for the v-component occurs when the range value is set to 28.0 km. A range value of 24.0 km gives the best average RMSVD value.

Figure 28a through 28h examines how the (r^2) value changes for the different range values for the lower levels of the atmosphere at 900 m, 1200 m, 2100 m, and 2400 m respectively.

The only improvement in the (r^2) value for the u-component occurs at 1200 m when the range value is decreased to 20.0 km, as shown in Figure 28c. The p-value at this height decreases from 0.051 for the default range value of 30 km to 0.009 for the range value at 20.0 km, indicating a high level of reliability.

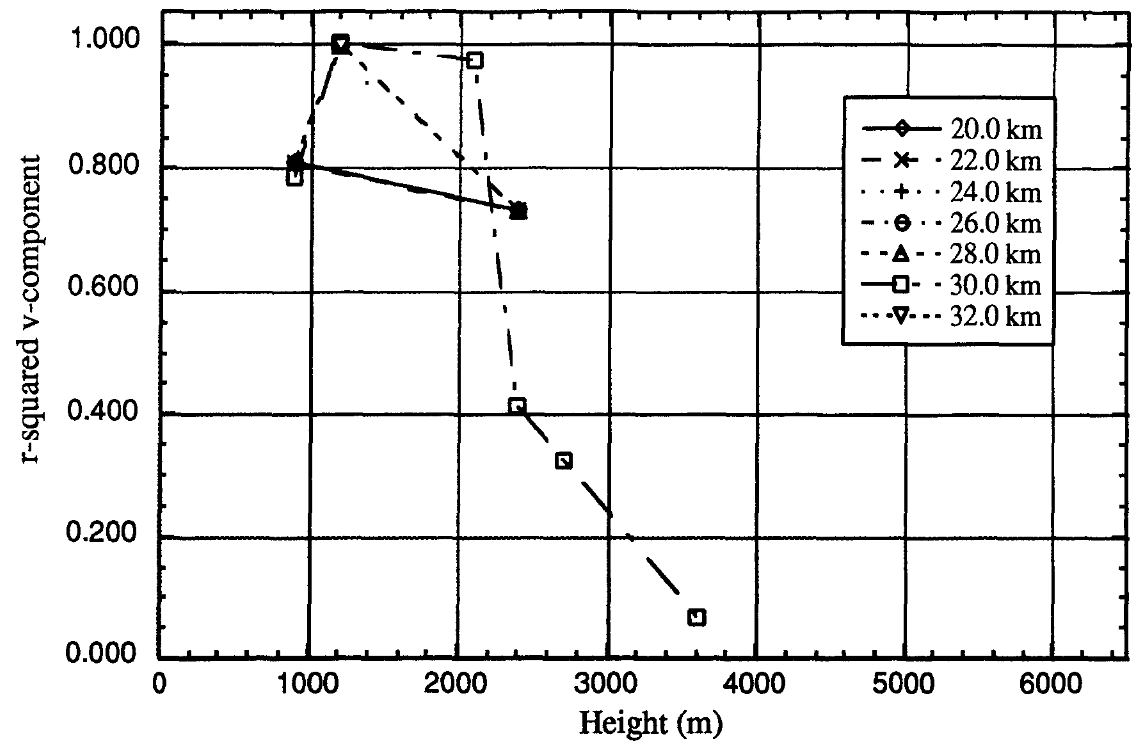
The (r^2) value is also improved for the v-component at 1200 m when the range value is decreased to 20.0 km, as shown in Figure 28d. However, the p-value increases from zero for the default value of 30.0 km to 0.004 for the range value of 20.0 km. This is still an acceptable level of certainty. Figure 28h shows the (r^2) value also increases for the v-component at 2400 m when the range value is between 28.0 km and 22.0 km. The p-value for the default value 30.0 km is 0.213 and decreases to 0.17 for the other range values. This is still above the level of significance and indicates a high level of uncertainty.

Therefore, for the summer season based on a small sample size, a tentative conclusion can be made that changing the range parameter will improve the agreement between the VAD winds and the rawinsonde wind data at some of the lower heights in the atmosphere, but will cause the VAD winds to be worse at other heights. No single range value causes the best improvement.



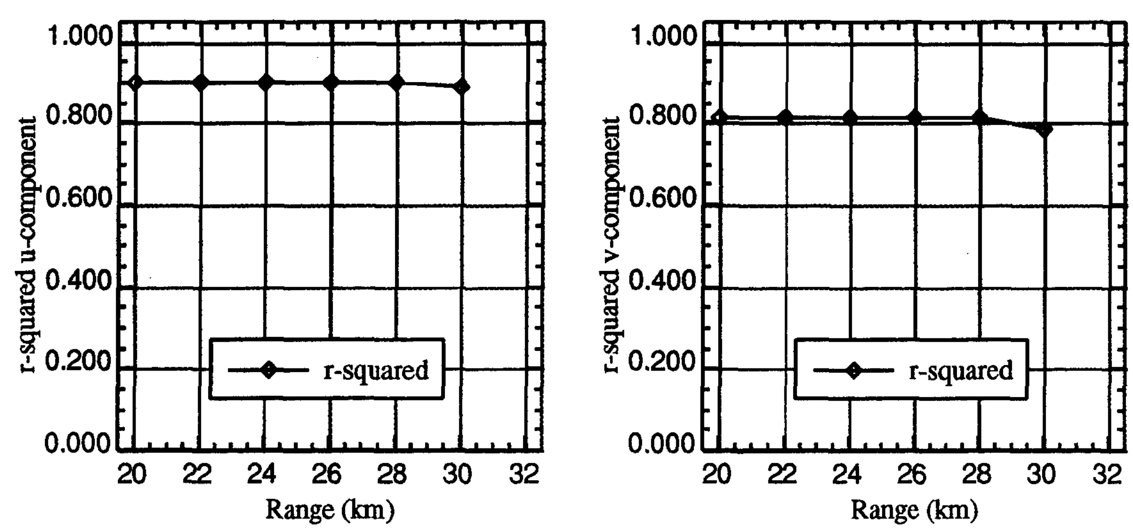
r-squared u-component
1.000
0.800
0.600
0.400
0.200
0.000
0
1000
2000
3000
4000
5000
6000
Height (m)
20.0 km
22.0 km
24.0 km
26.0 km
28.0 km
30.0 km
32.0 km

(a)



(b)

FIG. 21. Coefficient of determination (r^2) with height between the VAD wind (modified) and the rawinsonde wind data for the fall season at Vandenberg: (a) u-component; (b) v-component. <u>Note:</u> Some heights will not have a plot if (r^2) could not be computed due to zero, one, or two matches.



(a) (b)

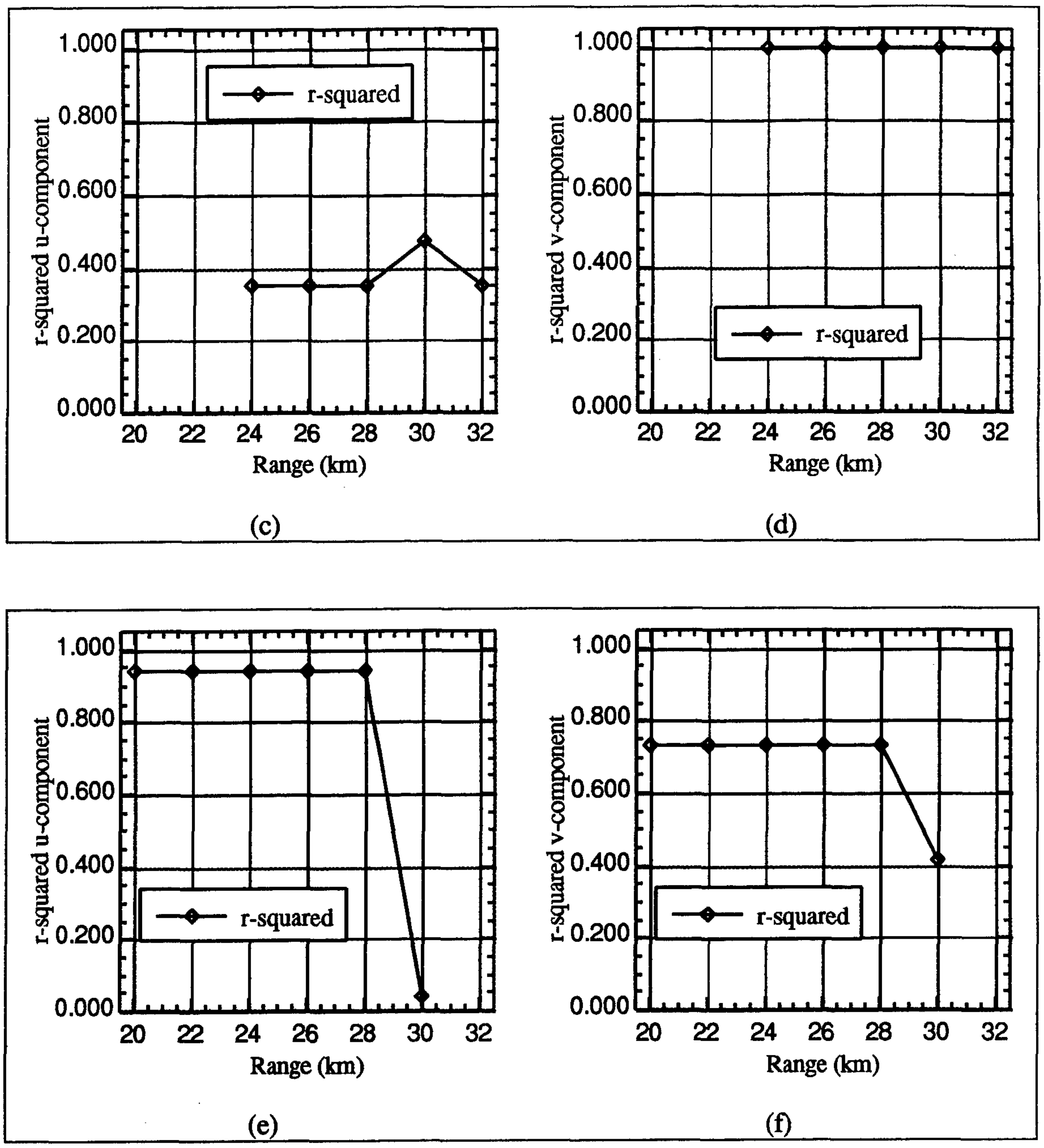
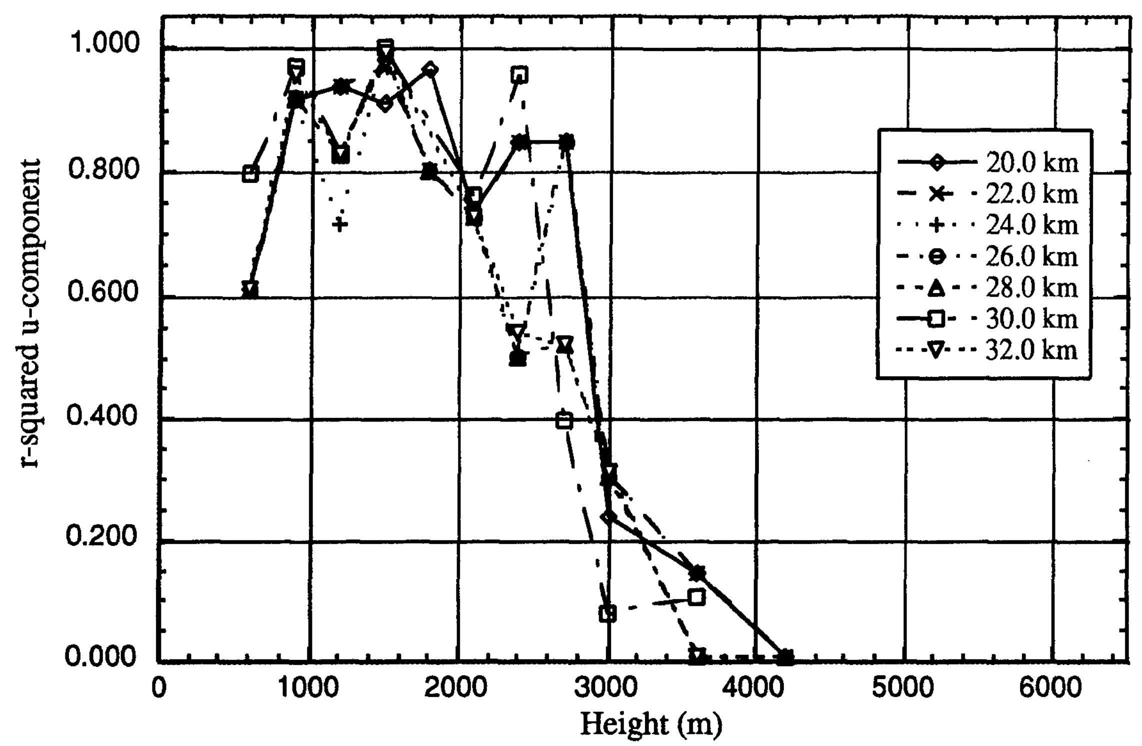
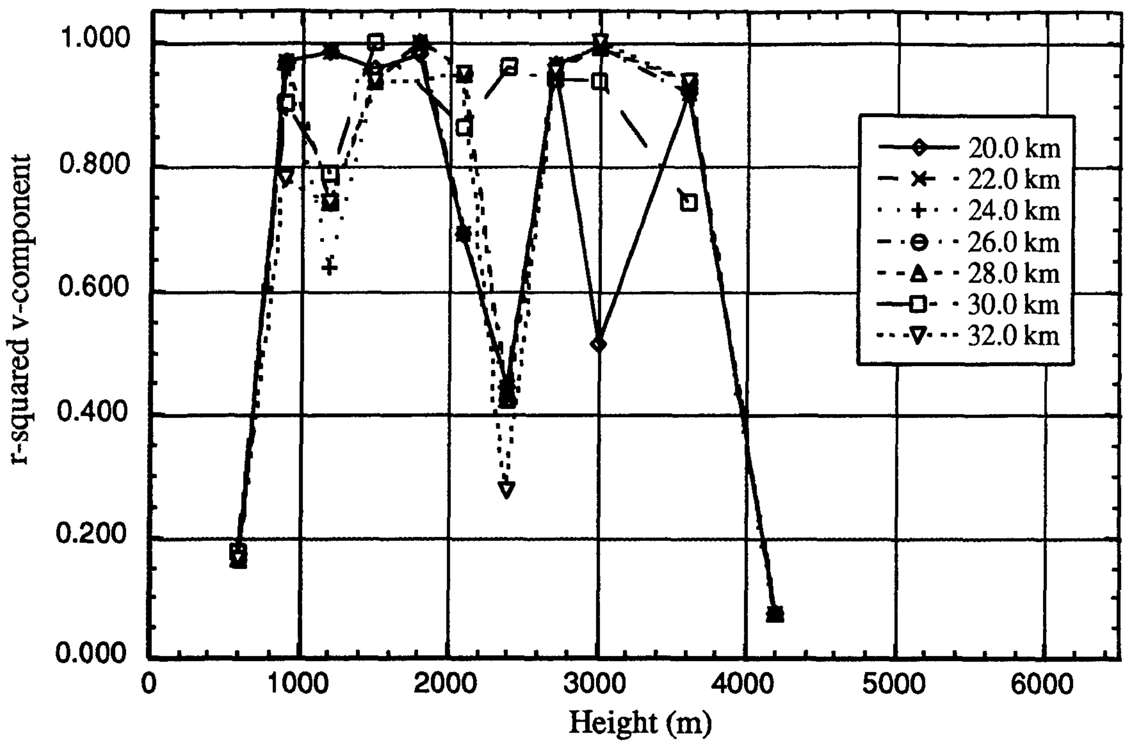


FIG. 22. Coefficient of determination (r^2) values for specific low-level heights from modified values of the range adaptable parameter between the VAD wind (modified) and the rawinsonde wind data in the fall season: (a) 900 m u-component; (b) 900 m v-component; (c) 1200 m u-component; (d) 1200 m v-component; (e) 2400 m u-component; (f) 2400 m v-component.

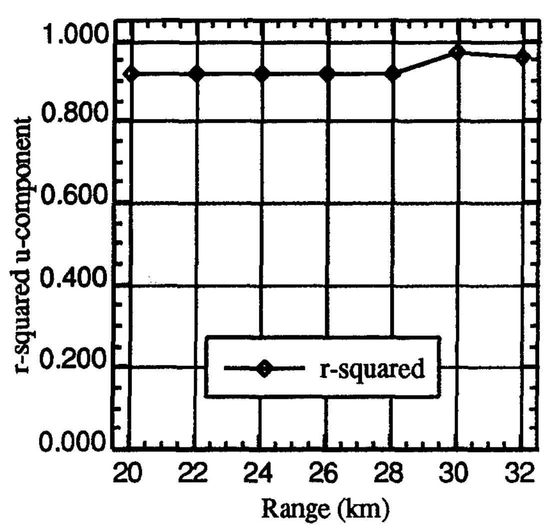

1.000
0.800
0.600
0.400
0.200
0.000
r-squared u-component
0
1000
2000
3000
4000
5000
6000
Height (m)
20.0 km
22.0 km
24.0 km
26.0 km
28.0 km
30.0 km
32.0 km

(a)

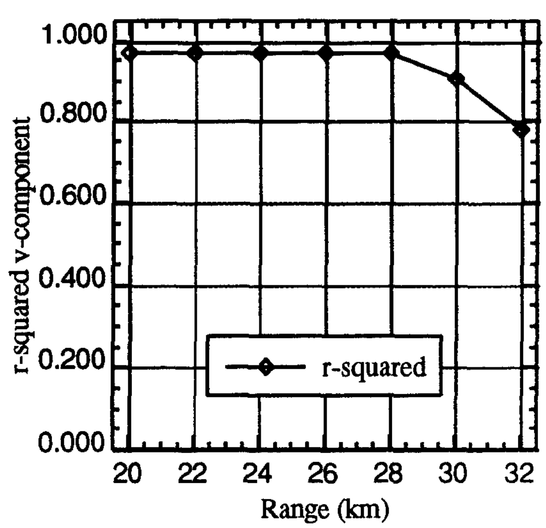


(b)

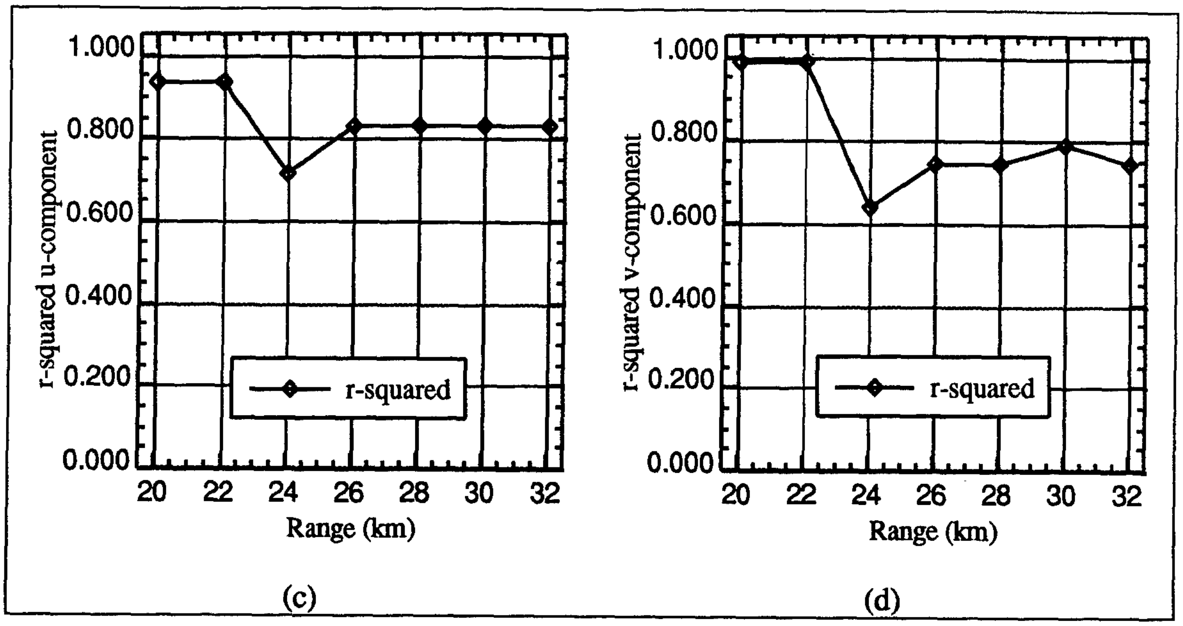
FIG. 23. Coefficient of determination (r^2) with height between the VAD wind (modified) and the rawinsonde wind data for the winter season at Vandenberg: (a) u-component; (b) v-component. <u>Note:</u> Some heights will not have a plot if (r^2) could not be computed due to zero, one, or two matches.

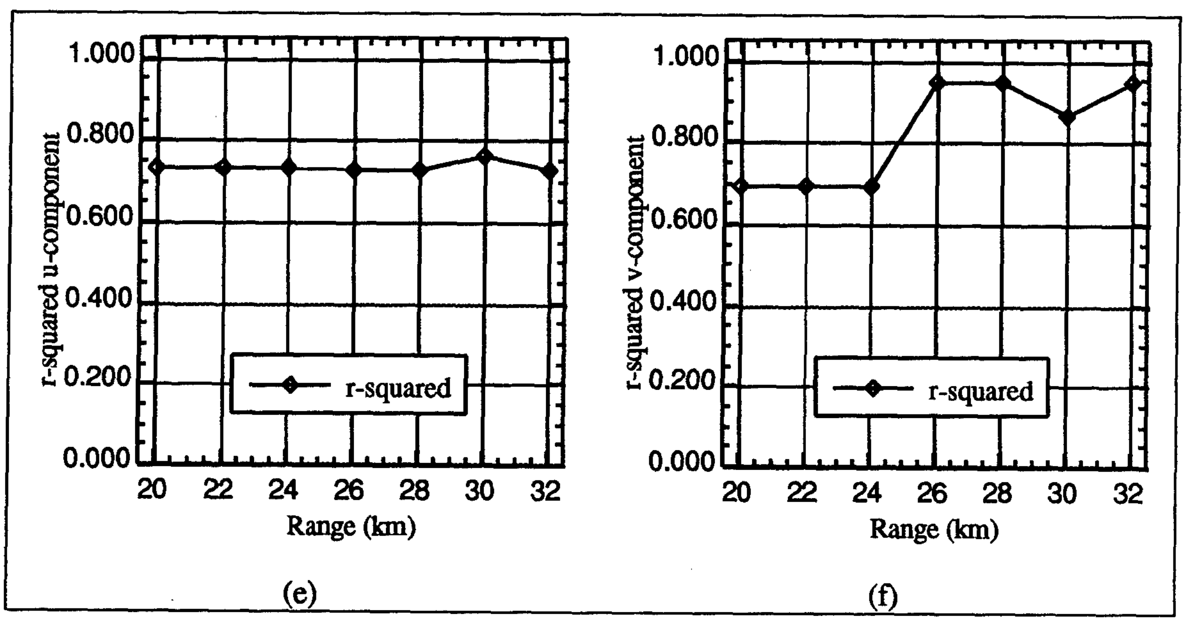


(a)



(b)


1.000
0.800
0.600
0.400
0.200
0.000
r-squared u-component
r-squared
20 22 24 26 28 30 32
Range (km)
(c)
1.000
0.800
0.600
0.400
0.200
0.000
r-squared v-component
r-squared
20 22 24 26 28 30 32
Range (km)
(d)


1.000
0.800
0.600
0.400
0.200
0.000
r-squared u-component
r-squared
20 22 24 26 28 30 32
Range (km)
(e)
1.000
0.800
0.600
0.400
0.200
0.000
r-squared v-component
r-squared
20 22 24 26 28 30 32
Range (km)
(f)

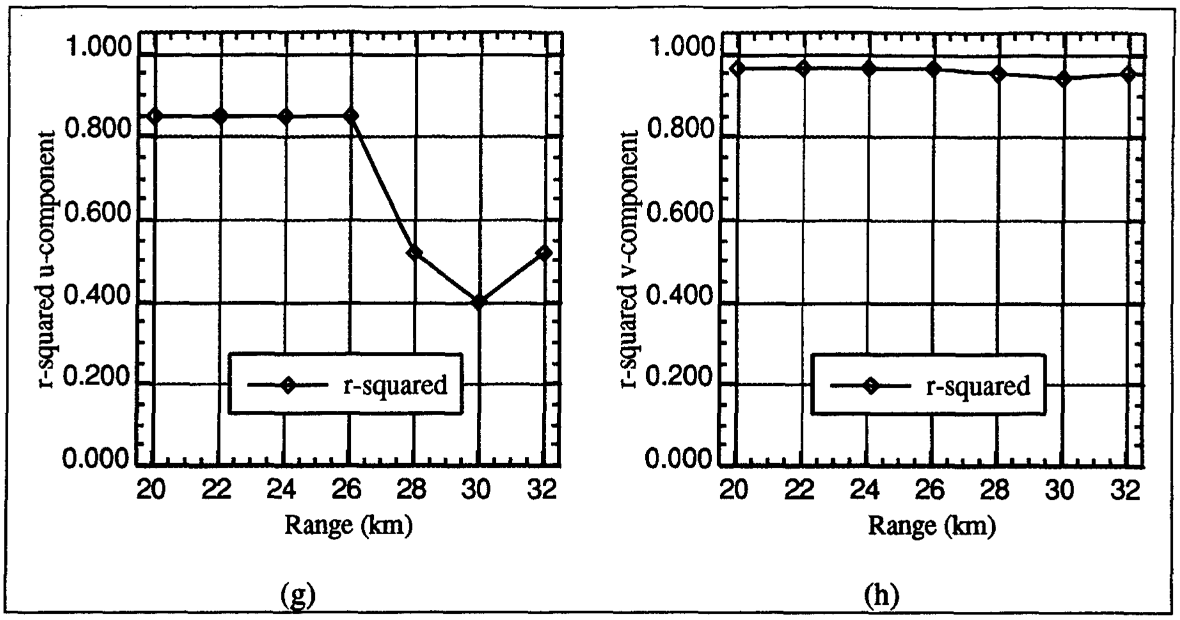
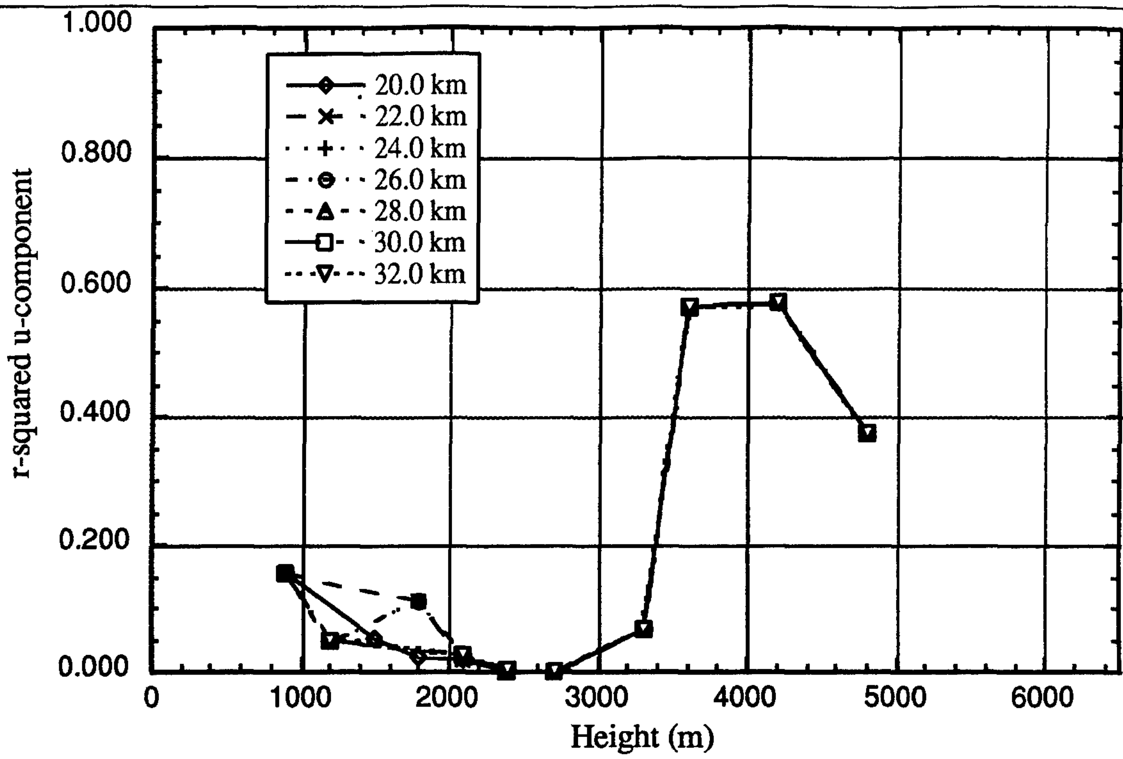
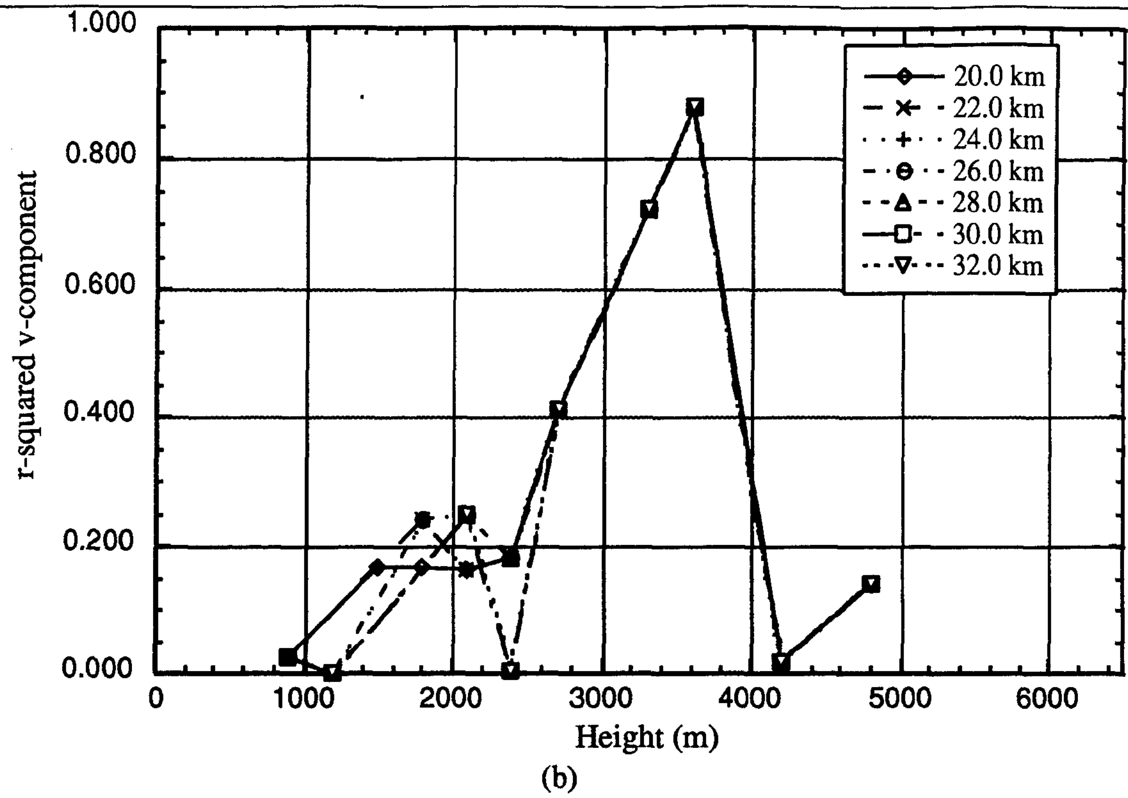


FIG. 24. Coefficient of determination (r^2) values for specific low-level heights from modified values of the range adaptable parameter between the VAD wind (modified) and the rawinsonde wind data in the winter season: (a) 900 m u-component; (b) 900 m v-component; (c) 1200 m u-component; (d) 1200 m v-component; (e) 2100 m u-component; (f) 2100 m v-component; (g) 2700 m u-component; (h) 2700 m v-component.



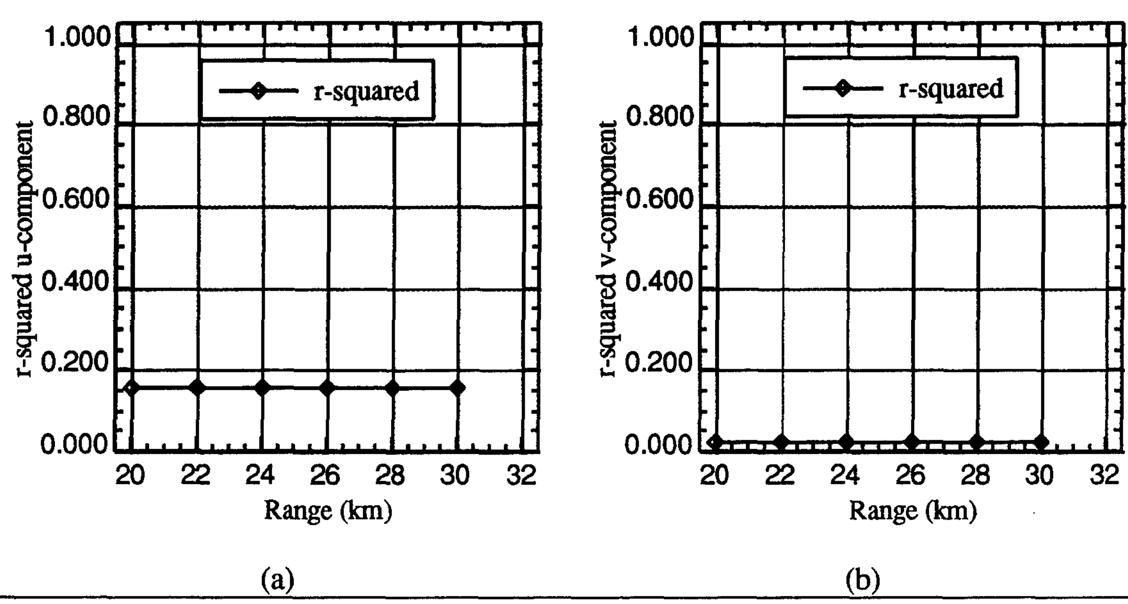
1.000
0.800
0.600
0.400
0.200
0.000
r-squared u-component
20.0 km
22.0 km
24.0 km
26.0 km
28.0 km
30.0 km
32.0 km
0
1000
2000
3000
4000
5000
6000
Height (m)

(a)



(b)

FIG. 25. Coefficient of determination (r^2) with height between the VAD wind (modified) and the rawinsonde wind data for the spring season at Vandenberg: (a) u-component; (b) v-component. Note: Some heights will not have a plot if (r^2) could not be computed due to zero, one, or two matches.



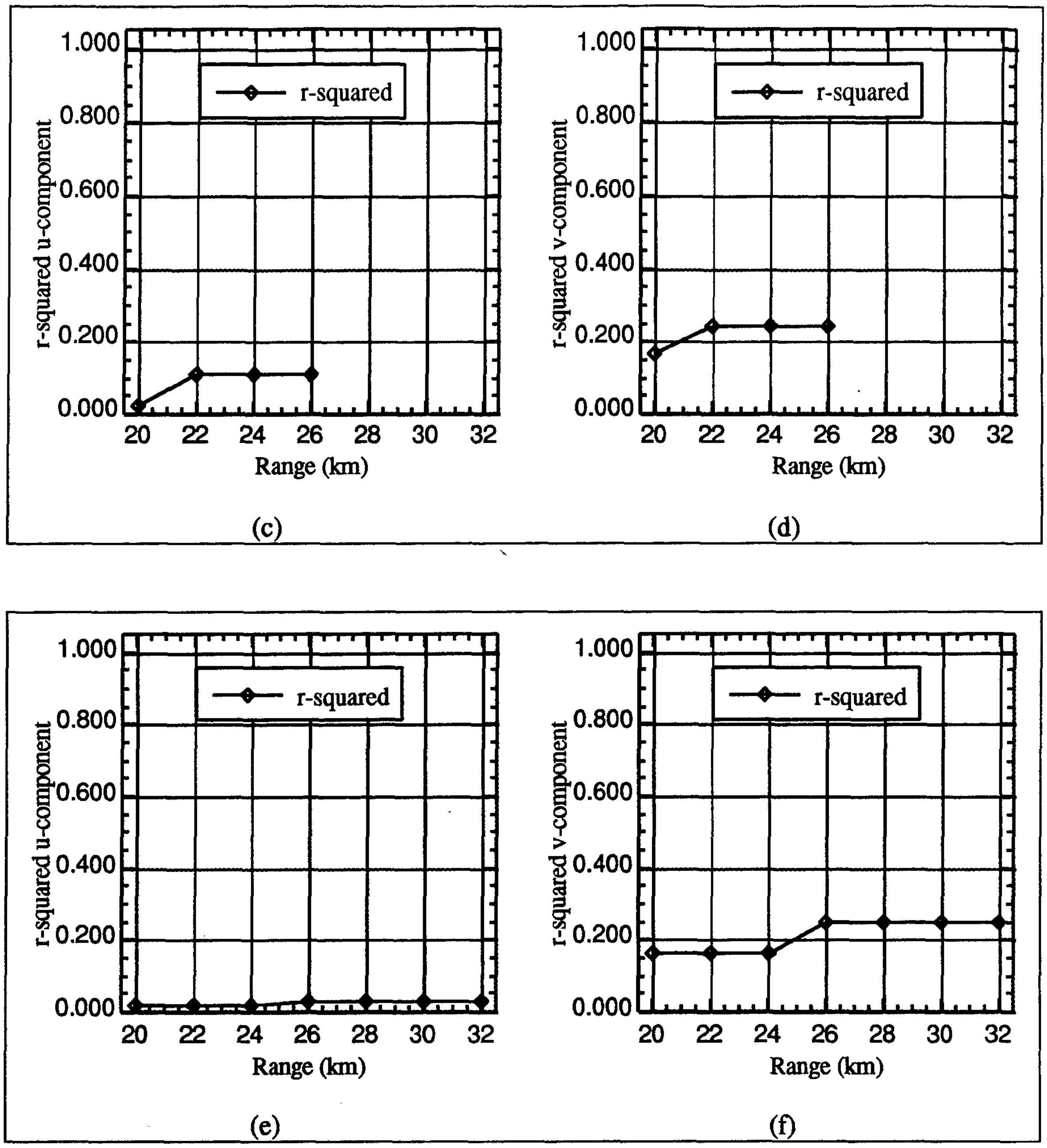
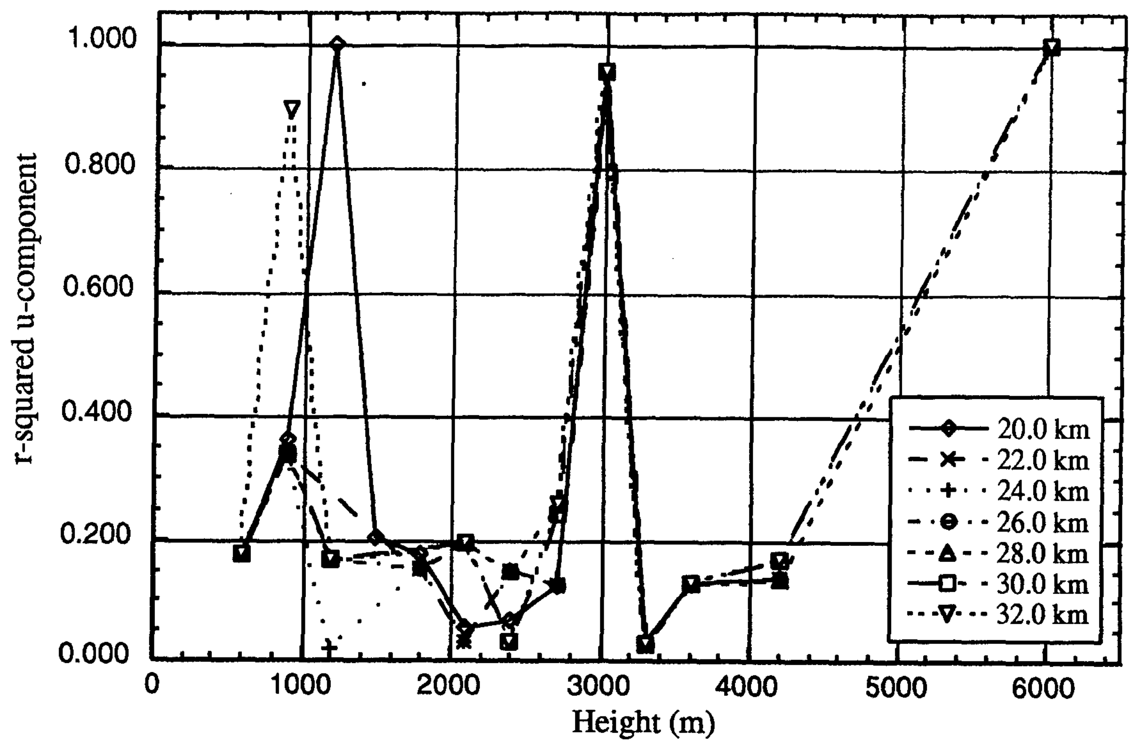
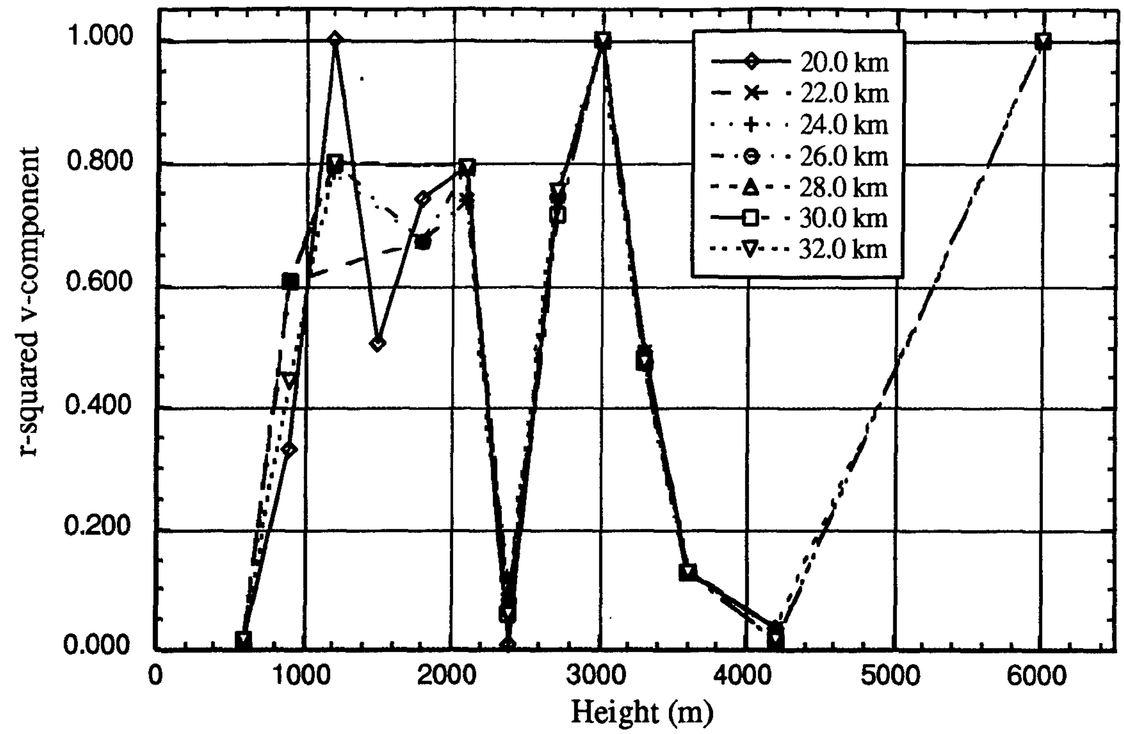


FIG. 26. Coefficient of determination (r^2) values for specific low-level heights from modified values of the range adaptable parameter between the VAD wind (modified) and the rawinsonde wind data in the spring season: (a) 900 m u-component; (b) 900 m v-component; (c) 1800 m u-component; (d) 1800 m v-component; (e) 2100 m u-component; (f) 2100 m v-component.

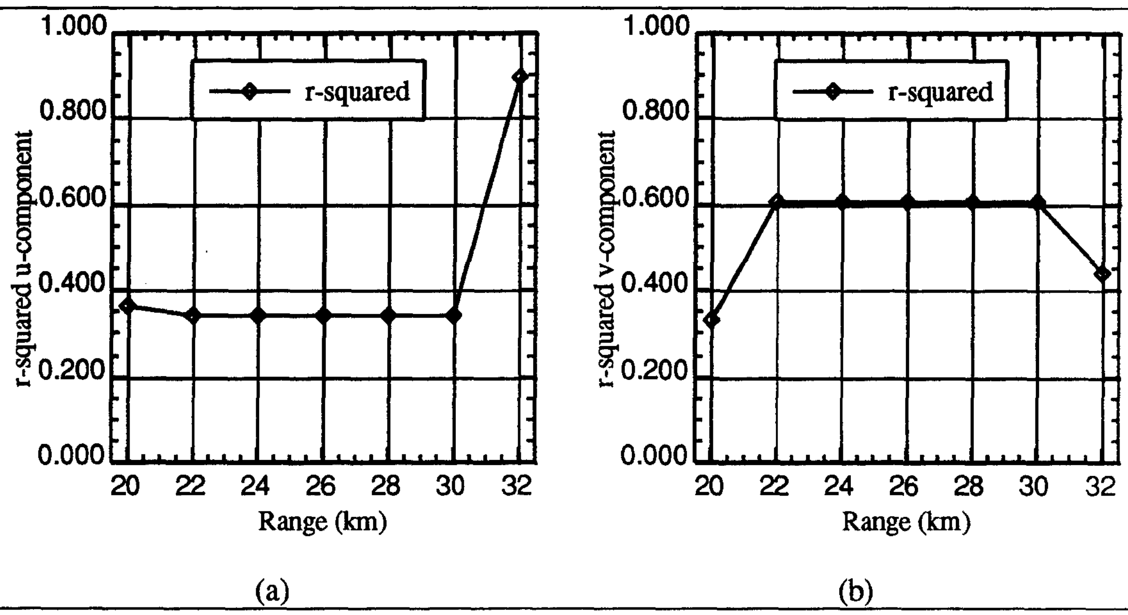

1.000
0.800
0.600
0.400
0.200
0.000
r-squared u-component
0
1000
2000
3000
4000
5000
6000
Height (m)
20.0 km
22.0 km
24.0 km
26.0 km
28.0 km
30.0 km
32.0 km

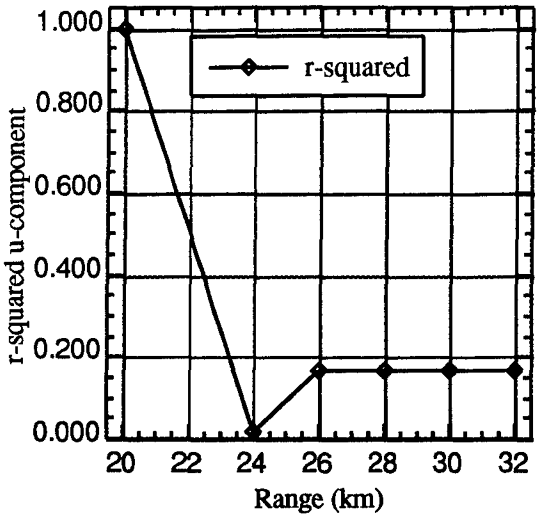
(a)



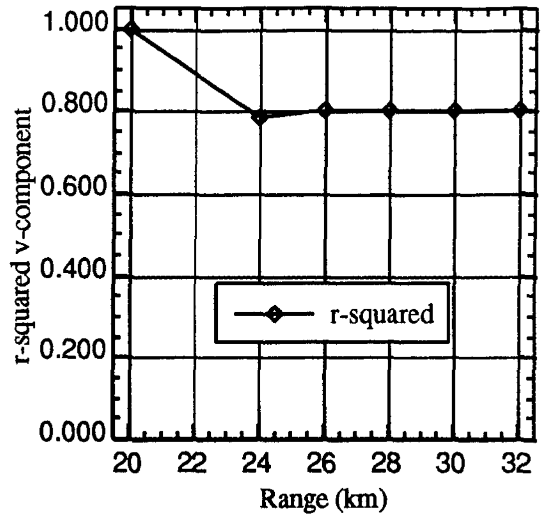
(b)

FIG. 27. Coefficient of determination (r^2) with height between the VAD wind (modified) and the rawinsonde wind data for the summer season at Vandenberg: (a) u-component; (b) v-component. Note: Some heights will not have a plot if (r^2) could not be computed due to zero, one, or two matches.

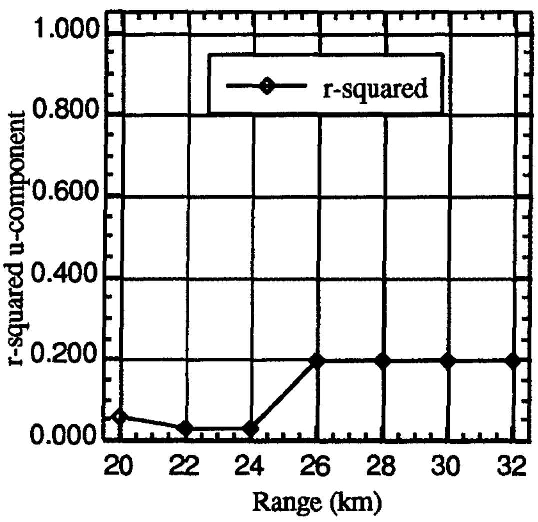



1.000
0.800
0.600
0.400
0.200
0.000
r-squared u-component
20 22 24 26 28 30 32
Range (km)
r-squared

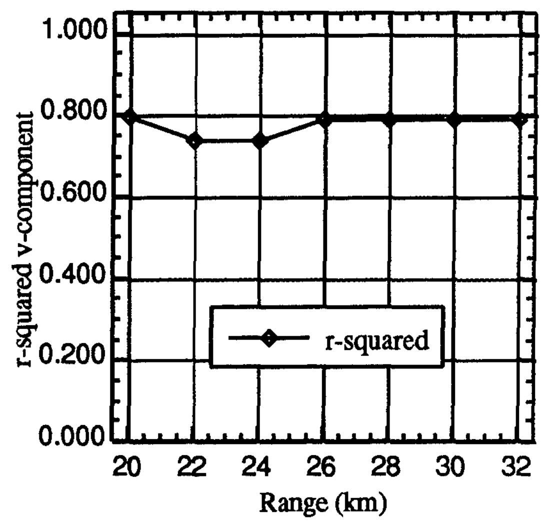
(c)


1.000
0.800
0.600
0.400
0.200
0.000
r-squared v-component
20 22 24 26 28 30 32
Range (km)
r-squared

(d)


1.000
0.800
0.600
0.400
0.200
0.000
r-squared u-component
20 22 24 26 28 30 32
Range (km)
r-squared

(e)


1.000
0.800
0.600
0.400
0.200
0.000
r-squared v-component
20 22 24 26 28 30 32
Range (km)
r-squared

(f)

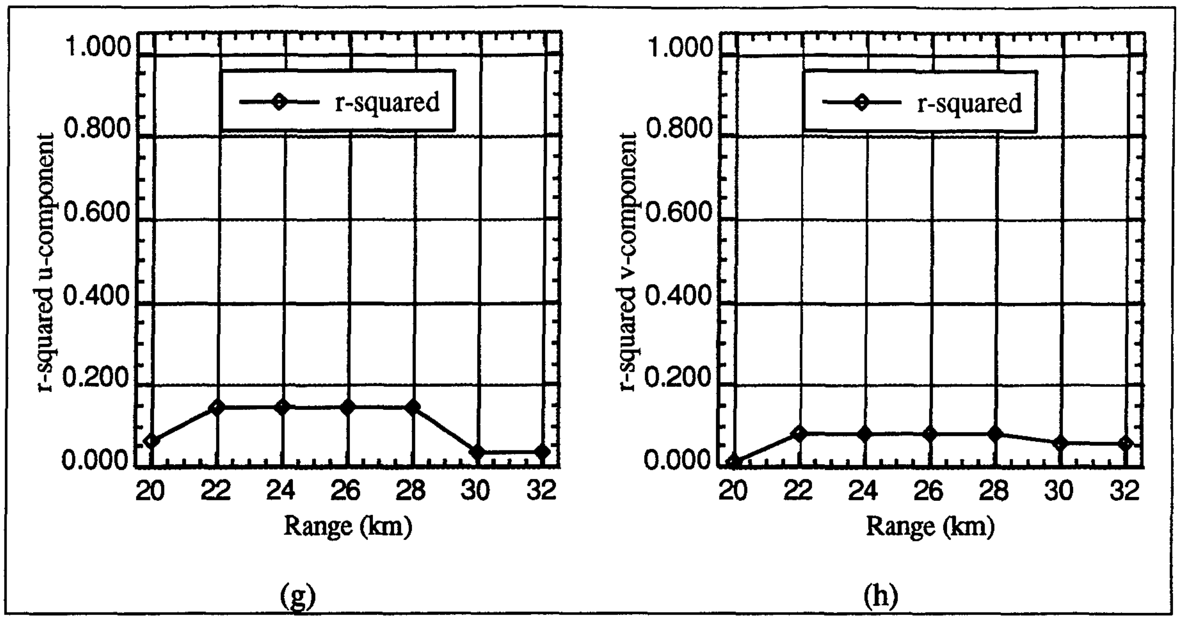


FIG. 28. Coefficient of determination (r^2) values for specific low-level heights from modified values of the range adaptable parameter between the VAD wind (modified) and the rawinsonde wind data in the summer season: (a) 900 m u-component; (b) 900 m v-component; (c) 1200 m u-component; (d) 1200 m v-component; (e) 2100 m u-component; (f) 2100 m v-component; (g) 2400 m u-component; (h) 2400 m v-component.

TABLE 18. Number of matched pairs between the VAD wind (modified) and the rawinsonde wind data in the fall season modifying the range adaptable parameter.

Range Value (km)	32.0	30.0 (Default)	28.0	26.0	24.0	22.0	20.0
Height (m)							
600	0	0	0	0	0	0	0
900	0	3	3	3	3	3	3
1200	3	3	3	3	3	0	0
1500	0	0	0	0	0	0	2
1800	0	0	0	1	1	1	1
2100	1	3	1	1	2	2	2
2400	1	3	3	3	3	3	3
2700	2	3	2	2	2	2	2
3000	0	0	0	0	0	0	0
3300	1	2	1	1	1	1	1
3600	2	3	2	2	2	2	2
3900	1	0	1	1	1	1	1
4200	2	1	2	2	2	2	2
4500	0	0	0	0	0	0	0
4800	1	1	1	1	1	1	1
5100	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0

TABLE 19. Average coefficient of determination (r^2) values and average RMSVD values for comparison between the VAD wind (modified) and the rawinsonde wind data sets for the fall season, modifying the range adaptable parameter.

Range Value	Avg (r^2) u-component	Avg (r^2) v-component	Avg RMSVD (kts)
32.0	0.350	0.997	8.438
30.0 (Default)	0.329	0.594	7.570
28.0	0.731	0.846	7.534
26.0	0.731	0.846	8.316
24.0	0.731	0.846	7.566
22.0	0.921	0.771	7.403
20.0	0.921	0.771	7.857

TABLE 20. Number of matched pairs between the VAD wind (modified) and the rawinsonde wind data in the winter season modifying the range adaptable parameter.

Range Value (km)	32.0	30.0 (Default)	28.0	26.0	24.0	22.0	20.0
Height (m)							
600	10	10	10	10	10	10	10
900	7	8	8	8	8	8	8
1200	10	8	10	10	11	7	7
1500	4	3	4	4	4	6	7
1800	2	2	5	5	5	5	6
2100	6	6	6	6	4	4	4
2400	7	4	4	4	4	4	4
2700	6	5	6	4	4	4	4
3000	4	5	4	4	4	4	5
3300	2	2	2	2	2	2	2
3600	4	5	4	4	5	5	5
3900	0	0	0	0	0	0	0
4200	1	2	6	6	6	6	6
4500	0	0	0	0	0	0	0
4800	1	1	1	1	1	1	0
5100	0	0	0	0	0	0	0
5400	0	0	0	0	1	1	1
5700	0	0	0	0	0	0	0
6000	2	2	2	2	2	2	2

TABLE 21. Average coefficient of determination (r^2) values and average RMSVD values for comparison between the VAD wind (modified) and the rawinsonde wind data sets for the winter season, modifying the range adaptable parameter.

Range Value	Avg (r^2) u-component	Avg (r^2) v-component	Avg RMSVD (kts)
32.0	0.611	0.749	9.224
30.0 (Default)	0.655	0.813	8.204
28.0	0.566	0.740	8.746
26.0	0.596	0.742	9.220
24.0	0.598	0.707	9.680
22.0	0.648	0.741	9.762
20.0	0.651	0.697	10.754

TABLE 22. Number of matched pairs between the VAD wind (modified) and the rawinsonde wind data in the spring season modifying the range adaptable parameter.

Range Value (km)	**32.0**	**30.0 (Default)**	**28.0**	**26.0**	**24.0**	**22.0**	**20.0**
Height (m)							
600	2	2	2	2	2	2	2
900	1	16	16	16	16	16	16
1200	14	14	14	14	14	0	0
1500	0	0	0	0	0	0	17
1800	0	0	0	17	17	17	14
2100	17	17	17	17	13	13	13
2400	18	18	13	13	13	13	13
2700	11	11	11	11	11	11	11
3000	2	2	2	2	2	2	2
3300	8	8	8	8	8	8	8
3600	6	6	6	6	6	6	6
3900	0	0	0	0	0	0	0
4200	6	6	6	6	6	6	6
4500	0	0	0	0	0	0	0
4800	6	6	6	6	6	6	6
5100	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0
6000	1	1	1	1	1	1	1

TABLE 23. Average coefficient of determination (r^2) values and average RMSVD values for comparison between the VAD wind (modified) and the rawinsonde wind data sets for the spring season, modifying the range adaptable parameter.

Range Value	Avg (r^2) u-component	Avg (r^2) v-component	Avg RMSVD (kts)
32.0	0.611	0.749	9.224
30.0 (Default)	0.203	0.272	21.763
28.0	0.203	0.292	21.567
26.0	0.194	0.287	21.369
24.0	0.193	0.278	21.092
22.0	0.208	0.309	21.072
20.0	0.184	0.287	20.631

TABLE 24. Number of matched pairs between the VAD wind (modified) and the rawinsonde wind data in the summer season modifying the range adaptable parameter.

Range Value (km)	32.0	30.0 (Default)	28.0	26.0	24.0	22.0	20.0
Height (m)							
600	6	6	6	6	6	6	6
900	3	22	22	22	22	22	20
1200	17	17	17	17	16	1	3
1500	2	2	2	2	2	2	15
1800	0	0	0	15	15	15	10
2100	15	15	15	15	15	15	15
2400	13	13	13	13	13	13	13
2700	12	11	12	13	13	13	13
3000	3	3	3	3	3	3	3
3300	14	14	14	14	14	14	14
3600	10	10	10	10	10	10	10
3900	0	0	0	0	0	0	0
4200	8	8	9	9	9	9	9
4500	0	0	0	0	0	0	0
4800	1	1	1	1	1	1	2
5100	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0
6000	3	3	3	2	2	2	2

TABLE 25. Average coefficient of determination (r^2) values and average RMSVD values for comparison between the VAD wind (modified) and the rawinsonde wind data sets for the summer season, modifying the range adaptable parameter.

Range Value	Avg (r^2) u-component	Avg (r^2) v-component	Avg RMSVD (kts)
32.0	0.364	0.498	11.451
30.0 (Default)	0.313	0.509	11.364
28.0	0.322	0.517	11.386
26.0	0.233	0.487	11.306
24.0	0.204	0.480	11.281
22.0	0.223	0.452	12.381
20.0	0.285	0.483	12.981

7. Summary and conclusions

a) Findings

There is no simple solution to optimizing the VAD algorithm's adaptable parameters. For all of the comparisons between the three different types of wind systems, all of the VAD adaptable parameters, with the exception of the range adaptable parameter, showed only some incremental improvement when the values of the adaptable parameters were modified from the default value. For example, changing the Threshold Symmetry (THY) adaptable parameter resulted in the (r^2) value improving by 0.01 or less. However, the values for these six adaptable parameters were only changed twice – an increment of 2.0 higher than the default value, and an increment of 2.0 lower than the default value. Changing these values of these adaptable parameters more than just twice might show a greater improvement in the coefficient of determination (r^2) values, but since these six adaptable parameters only adjust the statistical calculations of the VAD wind data, it is probably unlikely.

Another finding for all comparisons between the three types of wind systems was that any improvement made to the average RMSVD value from changing any of the adaptable parameters was less than one knot. Since this change is so small, no significant conclusions can be drawn since the improvement could possibly be due to meteorological noise.

The VAD range adaptable parameter was the only parameter that showed any significant improvement in the (r^2) value, which agreed with the previous studies mentioned in Chapter 2. Unfortunately, no single range value could be determined to work the best for all cases. The degree to which the range value or any other adaptable parameter can optimize the performance of the VAD algorithm is definitely season dependent. From other research conducted in this area, it is mostly likely station dependent as well. Overall, changing the VAD range value during low-level inversions might help improve the VAD winds at one height, but it will probably make the VAD winds at another height unreliable. There is no value for the range adaptable parameter that will clearly improve the VAD winds at all levels of the atmosphere. Also, while the data from the comparisons suggest that changing the VAD range value might also improve the u-component of the wind at a particular height, but will make the v-component of the wind worse, or vice versa. This is probably not real, and is due to the relationship between the radar beam, the prevailing wind direction, and the topography surrounding Vandenberg, Therefore, it will be up to the forecaster to decide which levels of the atmosphere are the most important when deciding whether to change the value of the range adaptable parameter.

b) Recommendations

From the research conducted for this thesis, the conclusions made from the comparison between the wind profiler and the VAD wind data are probably legitimate since there is a large sample size, although the sample size for the fall season is fairly low,

and must be carefully considered. All of the conclusions for the comparisons between the VAD data and the rawinsonde wind data or the conclusion for the comparison between the rawinsonde and wind profiler data must also be carefully considered since the sample sizes are extremely low. At best, the data might indicate a trend, but more data is needed to support a conclusion drawn from this data. Listed below are all of the conclusions made for each of the seasons for the three types of comparisons made.

1) FALL

The fall season had the second highest average (r^2) values for the original comparison between the wind profiler and the VAD (unmodified) wind data. It also had the second highest average (r^2) values for the comparison between the VAD (unmodified) wind and rawinsonde wind data. There were not enough matches in the fall season to calculate any statistics for the comparison between the rawinsonde and wind profiler data.

For the comparison between the wind profiler and the modified VAD wind data, decreasing the range value to 28.0 km or 26.0 km would not help the overall VAD wind data agree more with the wind profiler data, but could help a forecaster improve the representation of the winds in the lower levels of the atmosphere. However, this conclusion is based on a small sample size.

For the comparison between the modified VAD wind and the rawinsonde wind data, a reliable conclusion could not be drawn due to the extremely small sample size. Decreasing the range value appeared to help the overall VAD winds agree more with the rawinsonde

data. It also seemed to help the VAD winds at the lower levels of the atmosphere. However, the uncertainties were too high to have any confidence in this conclusion.

2) WINTER

The winter season had the highest average (r^2) values for the original comparison between the wind profiler and the VAD (unmodified) wind data. It also had the highest average (r^2) values for the comparison between the VAD (unmodified) wind and rawinsonde wind data. There were not enough matches in the winter season to calculate any statistics for the comparison between the rawinsonde and wind profiler data.

For the comparison between the wind profiler and the modified VAD wind data, decreasing the range value to 22.0 km or 20.0 km helped the overall VAD winds agree more with the wind profiler data. However, a forecaster should be aware that decreasing the range value will not improve the VAD winds at all levels of the atmosphere. No specific range value will improve the winds in the lower levels of the atmosphere.

For the comparison between the VAD wind and rawinsonde wind data, decreasing the range value was not effective for the overall VAD winds, but some improvement was made between the VAD wind data and the rawinsonde data in the lower levels of the atmosphere.

3) SPRING

The spring season had the lowest average (r^2) values for the original comparison between the wind profiler and the VAD (unmodified) wind data. It also had the lowest average (r^2) values for the comparison between the VAD (unmodified) wind and

rawinsonde wind data. There were only a maximum of four matches in the spring season to calculate statistics for the comparison between the rawinsonde and wind profiler data. The data did show relatively high (r^2) values between the four data points; however, a larger sample size is needed to confirm this conclusion.

For the comparison between the wind profiler and modified VAD wind data, decreasing the range value to 28.0 km or 22.0 km appears to help one component of the VAD winds agree more with the wind profiler, but not necessarily the other component. However, this is probably not physically real due to the reasons mentioned before. Decreasing the range to 28.0 km was probably the best value to use since the average (r^2) value for all heights was highest at this range value.

For the comparison between the VAD wind and the rawinsonde data, a reliable conclusion could not be made. The best value for the range parameter was to increase it to 32.0 km, which conflicts with all of the other results. However, there was also a high level of uncertainty with most of the data in this season.

4) Summer

The summer season had the third highest average (r^2) values for the original comparison between the wind profiler and the VAD (unmodified) wind data. It also had the third highest average (r^2) values for the comparison between the VAD (unmodified) wind and rawinsonde wind data. There were not enough matches in the summer season to calculate any statistics for the comparison between the rawinsonde and wind profiler data.

For the comparison between the wind profiler and the VAD wind data, the overall VAD winds were improved to agree more with the wind profiler data by decreasing the range value to 28.0 km. Furthermore, improvement of the winds at the lower levels of the atmosphere were made by decreasing the range value to 22.0 km.

For the comparison between the VAD wind and the rawinsonde wind data, decreasing the range parameter would improve the agreement between the VAD winds and the rawinsonde wind data at some heights, but cause the winds to be worse at other heights. No single range value causes the best improvement.

c) Future research

There are numerous opportunities in this area of research, or to build on this thesis. This study should be repeated a year after the wind profiler and rawinsonde at Vandenberg switch to separate frequencies, thus allowing a more accurate comparison to be made between these two types of systems. Also, a full two weeks worth of NEXRAD data could also be obtained for the fall season at Vandenberg. This research should also be further segmented by prevailing wind direction in order to try and explain the sharp differences between the u and v components of the wind when the VAD range adaptable parameter is changed. It would also be helpful to include days at Vandenberg with no inversions present in the atmosphere in order to examine the (r^2) values of the comparisons when the three systems should theoretically agree better.

The OSF is looking to test the performance of the VAD/VWP algorithm in geographically diverse sites. Originally, the goal of this thesis was to find optimal values

for the adaptable parameters for two other locations besides Vandenberg AFB. The NEXRAD radar at Norman, OK, has a nearby rawinsonde in Oklahoma City, OK, and a wind profiler close by in Purcell, OK. Also, the NEXRAD radar and rawinsonde in Denver, CO, has a nearby wind profiler in Platteville, CO. Selected dates between November 1995 and July 1996 were chosen for these additional two sites. Rawinsonde data and wind profiler data, along with corresponding NEXRAD tapes were received from the NCDC. However, due to time restraints, no research was able to be conducted on the adaptable parameters for these two stations. Anyone interested in using this data to conduct a similar study can contact the weather lab at AFIT at DSN 785-3636 X4646, or commercial (937) 255-3636 X4646.

Improvements in this area of research could also be made by focusing on modifying the adaptable parameters during specific times of the day. A study could be conducted to find what hours during the day have the highest and lowest (r^2) values.

Another direction for this research is to focus on inversions in the middle or upper troposphere. The data in this thesis was selected to hopefully improve the accuracy of the VAD wind data at lower heights in the atmosphere during low-level inversions.

APPENDIX A

Statistical relationships used in this study

Most of the statistical quantities used in this thesis are given in Devore (1995). The RMSVD value was calculated using the same method as Davis (1995).

a. Root Mean Square Vector Difference

$$RMSVD = \sqrt{N^{-1} \cdot \left[\sum_{i=1}^{N} \left[\left(U_a - U_b \right)_i \right]^2 + \left[\left(V_a - V_b \right)_i \right]^2 \right]}$$

U = u (east-west) wind component

V = v(north-south) wind component

a = value of first wind profiler system

b = value of second wind profiler system

The RMSVD was calculated for each of the three different comparisons between wind profiler systems:

wind profiler - VAD wind, VAD wind - rawinsonde, rawinsonde - profiler

N = total number of matched levels in a profile

i = ith level of a profile

b. Pearson correlation coefficient (r)

$$r = \rho = \rho(x,y) = \frac{\text{covariance}(x,y)}{\sigma_x \cdot \sigma_y}$$

σ_x = standard deviation of x

σ_y = *standard deviation of y*

c. Coefficient of determination (r^2)

$(r^2) = r*r$

d. t Test statistic for testing $H_o: \rho = 0$

$$T := \frac{r \cdot \sqrt{n-2}}{\sqrt{1-r^2}}$$

r = correlation of the u or v components between the two types of wind profilers

n = degrees of freedom

When H_o is true, T has a distribution with n-2 degrees of freedom.

For the alternative hypothesis H_a: $\rho \neq 0$, the rejection region for a Level α test is:

either $t \geq t_{\alpha/2,\, n-2}$ or $t \leq -t_{\alpha/2,\, n-2}$

e.. P-value for a t test

If correlation (r) is > 0 then

Pvalue := 1 − pt(Tstar, df)

If correlation (r) is < 0 then

$$Pvalue := pt(Tstar, df)$$

pt = cumulative probability

Tstar = calculated value of t test statistic

df = degrees of freedom

APPENDIX B

This appendix lists the statistical data calculated for the comparisons discussed in Chapter 4. The first section is the comparison between the wind profiler data and the original, unmodified VAD wind data. The second section is the comparison between the rawinsonde data and the original, unmodified VAD wind data. The third section is the comparison between the rawinsonde data and the wind profiler data. Each section consists of four tables of data, one for each season examined. An explanation of the tables in this appendix is listed below:

Hgt (m) - Height
Rmsvd (kts) - Root Mean Square Vector Difference (knots)
(r) u - Correlation (r), U -component
(r) v - Correlation (r), V -component
(r^2) u - Coefficient of determination (r^2), U - component
(r^2) v - Coefficient of determination (r^2), V - component
tcrit u - Critical value of t-test for U - component
tstar u - Calculated value of t test statistic for U- component
pval u - P-value calculated for U -component
tcrit v - Critical value of t-test for V - component
tstar v - Calculated value of t test statistic for V -component
pval v - P-value calculated for V -component

Note:

In the following tables for appendix B, a height followed by all zeros in the same row indicates there were no matches found at that height, therefore none of the statistics were calculated for that height. A height followed by an RMSVD value, then a dummy value of 2 for the (r) and (r^2) values, indicates there were only 1 or 2 matches between the u and v components at this height. The RMSVD value can be calculated; however, for only 1 match, the (r) value would be infinite, for 2 matches, the (r) value would be 1. Therefore, for these cases, the dummy value of 2 was assigned to the (r) and (r^2) values. However, these values of 2 were not plotted in the graphical plots in Chapters 4, 5, and 6.

Section 1: Statistical data for the comparison between the wind profiler data and the original, unmodified VAD wind data

Vandenberg - Fall 1995: Profiler / VAD (unmodified)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	2.76	0.894	-0.967	0.8	0.934	4.303	2.825	0.053	-4.303	-5.339	0.017
750	5.063	-0.888	0.191	0.788	0.037	-4.303	-2.73	0.056	4.303	0.276	0.404
1000	7.968	-0.426	0.731	0.182	0.534	-2.02	-3.018	0.002	2.02	6.86	0
1250	8.072	-0.447	0.54	0.2	0.291	-2.03	-2.96	0.003	2.03	3.792	0
1500	5.224	2	2	2	2	0	0	0	0	0	0
1750	7.482	-0.803	-0.5	0.645	0.25	-12.706	-1.347	0.203	-12.706	-0.577	0.333
2000	12.6	0.434	0.29	0.188	0.084	2.074	2.257	0.017	2.074	1.424	0.084
2250	12.554	0.511	-0.346	0.261	0.12	2.074	2.787	0.005	-2.074	-1.731	0.049
2500	11.358	0.25	-0.249	0.062	0.062	2.086	1.152	0.131	-2.086	-1.15	0.132
2750	6.828	0.363	0.387	0.132	0.15	2.045	2.097	0.022	2.045	2.261	0.016
3000	6.912	0.259	0.299	0.067	0.089	2.037	1.519	0.069	2.037	1.771	0.043
3250	8.021	-0.514	0.306	0.264	0.094	-2.086	-2.679	0.007	2.086	1.438	0.083
3500	8.245	-0.542	0.228	0.294	0.052	-2.086	-2.884	0.005	2.086	1.049	0.153
3750	8.874	0.148	-0.033	0.022	0.001	2.028	0.898	0.187	-2.028	-0.199	0.422
4000	8.26	-0.236	0.253	0.056	0.064	-2.08	-1.113	0.139	2.08	1.198	0.122
4250	6.764	-0.014	0.483	0	0.233	-2.262	-0.042	0.484	2.262	1.653	0.066
4500	6.833	0.628	0.83	0.394	0.689	2.776	1.613	0.091	2.776	2.98	0.02
4750	0	0	0	0	0	0	0	0	0	0	0
5000	0	0	0	0	0	0	0	0	0	0	0
5250	0	0	0	0	0	0	0	0	0	0	0
5500	0	0	0	0	0	0	0	0	0	0	0
5750	0	0	0	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0	0	0	0

Avg. rmsvd = 7.872   Avg. (r^2) u = 0.272   Avg (r^2) v = 0.230

Vandenberg - Winter 1996: Profiler / VAD (unmodified)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	19.595	0.023	0.587	0.001	0.344	1.969	0.37	0.356	1.969	11.453	0
750	16.009	0.492	0.646	0.242	0.418	1.969	9.026	0	1.969	13.529	0
1000	14.77	0.612	0.703	0.375	0.494	1.969	12.61	0	1.969	16.093	0
1250	13.459	0.61	0.745	0.372	0.554	1.973	10.518	0	1.973	15.253	0
1500	10.922	0.799	0.837	0.639	0.701	1.977	15.852	0	1.977	18.233	0
1750	8.699	0.827	0.909	0.684	0.827	1.979	16.465	0	1.979	24.436	0
2000	14.735	0.804	0.136	0.646	0.019	1.973	18.573	0	1.973	1.893	0.03
2250	15.476	0.78	0.669	0.609	0.448	1.973	16.962	0	1.973	12.255	0
2500	14.165	0.767	0.755	0.588	0.57	1.975	15.292	0	1.975	14.741	0
2750	13.664	0.74	0.718	0.547	0.516	1.98	12.042	0	1.98	11.308	0
3000	17.909	0.669	0.589	0.448	0.347	1.982	9.364	0	1.982	7.58	0
3250	18.394	0.674	0.491	0.455	0.241	1.984	9.135	0	1.984	5.639	0
3500	19.146	0.609	0.477	0.371	0.227	1.984	7.674	0	1.984	5.42	0
3750	17.232	0.369	0.681	0.136	0.463	1.983	4.088	0	1.983	9.566	0
4000	7.432	0.777	0.889	0.603	0.79	1.988	11.367	0	1.988	17.906	0
4250	9.642	0.602	0.853	0.362	0.728	1.987	7.07	0	1.987	15.335	0
4500	7.217	0.75	0.919	0.563	0.844	1.99	10.083	0	1.99	20.699	0
4750	15.236	0.753	0.568	0.567	0.322	1.991	10.1	0	1.991	6.09	0
5000	14.954	0.715	0.63	0.511	0.827	1.991	9.028	0	1.991	7.156	0
5250	9.08	0.65	0.927	0.423	0.241	1.986	8.161	0	1.986	23.604	0
5500	8.733	0.75	0.935	0.562	0.322	1.987	10.683	0	1.987	24.941	0
5750	7.19	0.859	0.924	0.737	0.827	1.989	15.362	0	1.989	22.169	0
6000	7.732	0.848	0.918	0.719	0.241	1.988	14.731	0	1.988	21.313	0

Avg. rmsvd = 13.104 Avg. (r^2) u = 0.485 Avg (r^2) v = 0.492

Vandenberg - Spring 1996: Profiler / VAD (unmodified)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	$(r^2)u$	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	14.318	0.6	0.436	0.36	0.19	1.995	6.191	0	1.995	3.991	0
750	16.904	0.533	0.19	0.284	0.036	1.995	5.198	0	1.995	1.599	0.057
1000	20.028	0.359	-0.042	0.129	0.002	1.966	7.484	0	-1.966	-0.821	0.206
1250	19.746	0.356	0.04	0.127	0.002	1.967	7.048	0	1.967	0.734	0.232
1500	22.499	0.901	-0.336	0.812	0.113	2.032	12.128	0	-2.032	-2.082	0.022
1750	22.452	0.919	-0.326	0.844	0.106	2.045	12.528	0	-2.045	-1.858	0.037
2000	28.224	0.517	0.027	0.268	0.001	1.966	11.939	0	1.966	0.534	0.297
2250	29.627	0.503	-0.399	0.253	0.159	1.966	11.519	0	-1.966	-8.603	0
2500	28.708	0.501	-0.192	0.251	0.037	1.967	11.009	0	-1.967	-3.716	0
2750	25.9	0.476	-0.112	0.227	0.012	1.969	8.959	0	-1.969	-1.859	0.032
3000	26.398	0.507	-0.114	0.257	0.013	1.97	9.154	0	-1.97	-1.78	0.038
3250	26.462	0.489	-0.124	0.239	0.015	1.971	8.209	0	-1.971	-1.835	0.034
3500	27.77	0.481	-0.214	0.232	0.046	1.971	8.051	0	-1.971	-3.212	0.001
3750	27.232	0.481	-0.092	0.231	0.008	1.972	7.731	0	-1.972	-1.299	0.098
4000	27.408	0.449	-0.058	0.201	0.003	1.973	6.812	0	-1.973	-0.793	0.215
4250	26.435	0.57	0.059	0.324	0.003	1.972	9.776	0	1.972	0.831	0.203
4500	24.148	0.696	0.135	0.485	0.018	1.977	11.565	0	1.977	1.626	0.053
4750	26.736	0.659	-0.154	0.435	0.024	1.98	9.684	0	-1.98	-1.725	0.043
5000	26.463	0.665	-0.145	0.442	0.106	1.978	10.148	0	-1.978	-1.669	0.049
5250	26.376	0.777	-0.13	0.604	0.015	1.987	11.658	0	-1.987	-1.239	0.109
5500	29.732	0.592	-0.244	0.351	0.024	1.984	7.275	0	-1.984	-2.494	0.007
5750	29.889	0.691	-0.088	0.477	0.106	1.995	7.881	0	-1.995	-0.73	0.234
6000	25.539	0.833	0.342	0.694	0.015	2.026	9.162	0	2.026	2.21	0.017

Avg. rmsvd = 25.174 Avg. (r^2) u = 0.371 Avg (r^2) v = 0.046

Vandenberg - Summer 1996: Profiler / VAD (unmodified)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	8.828	0.446	0.493	0.199	0.243	1.983	5.085	0	1.983	5.777	0
750	12.17	0.314	0.208	0.098	0.043	1.983	3.371	0.001	1.983	2.17	0.016
1000	8.718	0.444	0.693	0.198	0.48	1.967	9.297	0	1.967	18.001	0
1250	9.583	0.276	0.712	0.076	0.507	1.968	5.036	0	1.968	17.757	0
1500	8.274	0.597	0.856	0.357	0.733	2.035	4.28	0	2.035	9.529	0
1750	10.586	0.099	0.353	0.01	0.124	2.052	0.519	0.304	2.052	1.959	0.03
2000	14.539	-0.118	-0.006	0.014	0	-1.969	-1.891	0.03	-1.969	-0.095	0.462
2250	12.761	-0.179	0.621	0.032	0.385	-1.969	-2.893	0.002	1.969	12.562	0
2500	13.726	-0.304	0.545	0.093	0.297	-1.971	-4.773	0	1.971	9.7	0
2750	12.194	0.075	0.702	0.006	0.492	1.971	1.097	0.137	1.971	14.44	0
3000	12.053	0.21	0.673	0.044	0.453	1.972	3.042	0.001	1.972	12.901	0
3250	13.46	0.296	0.598	0.087	0.358	1.973	4.233	0	1.973	10.203	0
3500	13.737	0.357	0.595	0.128	0.354	1.973	5.205	0	1.973	10.067	0
3750	14.191	0.24	0.632	0.057	0.399	1.974	3.192	0.001	1.974	10.529	0
4000	13.219	0.371	0.591	0.138	0.349	1.977	4.7	0	1.977	8.604	0
4250	11.898	0.234	0.326	0.055	0.106	1.977	2.836	0.003	1.977	4.065	0
4500	14.184	0	0.326	0	0.106	-1.988	-0.002	0.499	1.988	3.182	0.001
4750	22.281	-0.427	0.288	0.183	0.083	-2.032	-2.757	0.005	2.032	1.752	0.044
5000	20.212	0.06	0.256	0.004	0.124	2.024	0.371	0.356	2.024	1.635	0.055
5250	20.986	0.334	-0.22	0.111	0.358	2.228	1.119	0.145	-2.228	-0.714	0.246
5500	28.531	-0.531	0.814	0.282	0.083	-2.201	-2.078	0.031	2.201	4.649	0
5750	35.252	-0.895	0.752	0.801	0.124	-2.16	-7.223	0	2.16	4.108	0.001
6000	30.808	-0.792	0.667	0.627	0.358	-2.093	-5.652	0	2.093	3.903	0

Avg. rmsvd = 15.748 Avg. (r^2) u = 0.157 Avg (r^2) v = 0.285

Section 2: Statistical data for the comparison between the rawinsonde data and the original, unmodified VAD wind data

Vandenberg - Fall 1995: Rawinsonde / VAD (unmodified)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	0	0	0	0	0	0	0	0	0	0	0
900	10.223	-0.942	0.887	0.887	0.786	-12.706	-2.806	0.109	12.706	1.916	0.153
1200	9.847	-0.69	1	0.476	1	-12.706	-0.953	0.258	12.706	124.99	0.003
1500	0	0	0	0	0	0	0	0	0	0	0
1800	0	0	0	0	0	0	0	0	0	0	0
2100	13.908	-0.156	-0.987	0.024	0.974	-12.706	-0.157	0.45	-12.706	-6.089	0.052
2400	11.701	0.206	0.643	0.042	0.413	12.706	0.21	0.434	12.706	0.839	0.278
2700	6.453	-0.254	0.568	0.064	0.323	-12.706	-0.262	0.418	12.706	0.69	0.308
3000	0	0	0	0	0	0	0	0	0	0	0
3300	4.429	2	2	2	2	0	0	0	0	0	0
3600	6.741	0.693	0.258	0.481	0.067	12.706	0.962	0.256	12.706	0.267	0.417
3900	0	0	0	0	0	0	0	0	0	0	0
4200	0.194	2	2	2	2	0	0	0	0	0	0
4500	0	0	0	0	0	0	0	0	0	0	0
4800	4.637	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0	0	0	0

Avg. rmsvd = 7.570   Avg. (r^2) u = 0.329   Avg (r^2) v = 0.594

Vandenberg - Winter 1996: Rawinsonde / VAD (unmodified)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	20.238	0.893	0.421	0.797	0.177	2.306	5.61	0	2.306	1.312	0.113
900	8.235	0.984	0.951	0.969	0.904	2.447	13.628	0	2.447	7.523	0
1200	12.739	0.91	0.889	0.828	0.79	2.447	5.374	0.001	2.447	4.755	0.002
1500	2.456	1	0.999	1	0.999	12.706	80.252	0.004	2.447	27.713	0.011
1800	1.518	2	2	2	2	0	0	0	0	0	0
2100	3.362	0.872	0.929	0.761	0.864	2.776	3.568	0.012	2.776	5.032	0.004
2400	3.673	0.979	-0.981	0.958	0.962	4.303	6.731	0.011	-4.303	-7.078	0.01
2700	11.145	0.631	0.97	0.398	0.941	3.182	1.407	0.127	3.182	6.912	0.003
3000	13.3	-0.281	0.969	0.079	0.939	-3.182	-0.507	0.323	3.182	6.772	0.003
3300	2.766	2	2	2	2	0	0	0	0	0	0
3600	12.676	-0.325	0.863	0.105	0.744	-3.182	-0.595	0.297	3.182	2.956	0.03
3900	0	0	0	0	0	0	0	0	0	0	0
4200	10.009	2	2	2	2	0	0	0	0	0	0
4500	0	0	0	0	0	0	0	0	0	0	0
4800	2.804	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	9.921	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 8.204 Avg. (r^2) u = 0.655 Avg (r^2) v = 0.813

Vandenberg - Spring 1996: Rawinsonde / VAD (unmodified)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	5.563	2	2	2	2	0	0	0	0	0	0
900	20.169	0.396	-0.158	0.157	0.025	2.145	1.614	0.064	-2.145	-0.598	0.28
1200	21.336	-0.225	-0.046	0.05	0.002	-2.179	-0.798	0.22	-2.179	-0.161	0.437
1500	0	0	0	0	0	0	0	0	0	0	0
1800	0	0	0	0	0	0	0	0	0	0	0
2100	22.668	0.167	0.498	0.028	0.248	2.131	0.657	0.261	2.131	2.222	0.021
2400	22.655	0.066	-0.058	0.004	0.003	2.12	0.263	0.398	-2.12	-0.233	0.409
2700	19.232	-0.03	0.64	0.001	0.41	-2.262	-0.09	0.465	2.262	2.501	0.017
3000	5.193	2	2	2	2	0	0	0	0	0	0
3300	21.435	-0.257	0.85	0.066	0.722	-2.447	-0.652	0.265	2.447	2.153	0.03
3600	31.145	-0.754	0.937	0.569	0.877	-2.776	-2.297	0.042	2.776	5.342	0.003
3900	0	0	0	0	0	0	0	0	0	0	0
4200	29.216	0.76	0.136	0.578	0.019	2.776	2.339	0.04	2.776	0.275	0.399
4500	0	0	0	0	0	0	0	0	0	0	0
4800	29.285	0.611	0.376	0.373	0.142	2.776	1.542	0.099	2.776	0.812	0.231
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	33.252	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 21.763 Avg. (r^2) u = 0.203 Avg (r^2) v = 0.272

Vandenberg - Summer 1996: Rawinsonde / VAD (unmodified)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	10.553	0.419	0.118	0.176	0.014	2.776	0.923	0.204	2.776	0.238	0.412
900	8.78	0.583	0.779	0.34	0.606	2.086	3.208	0.002	2.086	5.548	0
1200	11.448	0.41	0.895	0.168	0.801	2.131	1.74	0.051	2.131	7.769	0
1500	2.373	2	2	2	2	0	0	0	0	0	0
1800	0	0	0	0	0	0	0	0	0	0	0
2100	12.628	0.443	0.89	0.196	0.792	2.16	1.781	0.049	2.16	7.03	0
2400	10.974	0.178	-0.242	0.032	0.059	2.201	0.601	0.28	-2.201	-0.828	0.213
2700	10.81	-0.492	0.846	0.242	0.715	-2.262	-1.696	0.062	2.262	4.751	0.001
3000	10.543	0.978	1	0.957	1	12.706	4.734	0.066	12.706	80.252	0.004
3300	12.33	0.168	0.689	0.028	0.474	2.179	0.59	0.285	2.179	2.42	0.019
3600	15.939	-0.361	0.358	0.13	0.128	-2.306	-1.093	0.153	2.306	1.086	0.155
3900	0	0	0	0	0	0	0	0	0	0	0
4200	13.658	-0.411	0.128	0.169	0.016	-2.447	-1.104	0.156	2.447	0.317	0.381
4500	0	0	0	0	0	0	0	0	0	0	0
4800	22.441	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	5.263	1	0.999	1	0.999	12.706	671088	0	12.706	25.981	0.012

Avg. rmsvd = 11.364 Avg. (r^2) u = 0.313 Avg (r^2) v = 0.509

Section 3: Statistical data for the comparison between the rawinsonde data and the wind profiler data

Vandenberg - Fall 1995: Rawinsonde / Profiler

Note: Due to all heights in this season only having 0, 1, or 2 matches, only the RMSVD values were calculated

Hgt (m)	rmsvd(kts)
500	7.428
750	2.067
1000	0.778
1250	2.708
1500	0.615
1750	0.991
2000	0.701
2250	1.661
2500	2.173
2750	0
3000	0
3250	3.445
3500	0
3750	2.365
4000	0
4250	0
4500	0
4750	0
5000	0
5250	0
5500	0
5750	3.018
6000	2.916

Avg. rmsvd = 2.374

Vandenberg - Winter 1996: Rawinsonde / Profiler

There were no matches between the rawinsonde data and the profiler data for this season.

Vandenberg - Spring 1996: Rawinsonde / Profiler

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	3.363	0.821	0.993	0.675	0.986	4.303	2.037	0.089	4.303	11.686	0.004
750	3.054	0.964	0.906	0.93	0.821	4.303	5.141	0.018	4.303	3.026	0.047
1000	2.971	0.926	0.901	0.857	0.812	4.303	3.466	0.037	4.303	2.937	0.05
1250	2.971	0.989	0.997	0.978	0.993	4.303	9.377	0.006	4.303	17.116	0.002
1500	10.954	0.475	0.825	0.226	0.68	4.303	0.764	0.262	4.303	2.063	0.088
1750	10.667	0.659	0.756	0.435	0.572	4.303	1.241	0.17	4.303	1.636	0.122
2000	21.223	0.097	0.1	0.009	0.01	4.303	0.138	0.451	4.303	0.143	0.45
2250	30.953	0.514	-0.9	0.264	0.81	4.303	0.847	0.243	-4.303	-2.92	0.05
2500	23.763	0.942	-0.756	0.887	0.571	4.303	3.967	0.029	-4.303	-1.632	0.122
2750	24.567	0.994	-0.766	0.988	0.586	4.303	12.746	0.003	-4.303	-1.683	0.117
3000	35.683	2	2	2	2	0	0	0	0	0	0
3250	3.683	2	2	2	2	0	0	0	0	0	0
3500	2.428	2	2	2	2	0	0	0	0	0	0
3750	28.497	0.847	-0.743	0.717	0.552	4.303	2.249	0.077	-4.303	-1.568	0.129
4000	0	0	0	0	0	0	0	0	0	0	0
4250	24.827	0.587	-0.872	0.345	0.761	4.303	1.025	0.207	-4.303	-2.521	0.064
4500	14.55	2	2	2	2	0	0	0	0	0	0
4750	21.061	0.991	-0.996	0.981	0.992	4.303	10.224	0.005	-4.303	-15.835	0.002
5000	2.963	0.998	0.996	0.997	0.992	4.303	24.566	0.001	4.303	15.993	0.002
5250	2.49	2	2	2	2	0	0	0	0	0	0
5500	4.308	2	2	2	2	0	0	0	0	0	0
5750	5.363	0.996	0.973	0.993	0.947	4.303	16.801	0.002	4.303	5.997	0.013
6000	7.28	0.997	0.982	0.993	0.965	4.303	16.904	0.002	4.303	7.392	0.009

Avg. rmsvd = 13.073 Avg. (r^2) u = 0.705 Avg (r^2) v = 0.753

Vandenberg - Summer 1996: Rawinsonde / Profiler

Note: Due to all heights in this season only having 0, 1, or 2 matches, only the RMSVD values were calculated

Hgt (m)	rmsvd (kts)
500	6.65
750	0.615
1000	1.182
1250	2.729
1500	2.147
1750	2.644
2000	4.119
2250	5.773
2500	4.206
2750	2.103
3000	0
3250	1.518
3500	0
3750	0.825
4000	0
4250	0.701
4500	0
4750	0
5000	0
5250	0
5500	0
5750	2.701
6000	1.375

Avg. rmsvd = 2.619

APPENDIX C

This appendix lists the statistical data calculated for the comparisons discussed in Chapter 5. This appendix lists the statistical data for the comparison between the wind profiler data and the modified VAD wind data. There are a total of 24 tables of statistical data. Each season has six tables corresponding to the six changes made to the VAD range adaptable parameter. These values are 28.0, 26.0, 24.0, 22.0, 20.0, and 32.0 km. The corresponding values for the default value of 30.0 km can be found in section one of appendix B. An explanation of the tables in this appendix is listed below:

Hgt (m) - Height

Rmsvd (kts) - Root Mean Square Vector Difference (knots)

(r) u - Correlation (r), U -component

(r) v - Correlation (r), V -component

(r^2) u - Coefficient of determination (r^2), U - component

(r^2) v - Coefficient of determination (r^2), V - component

tcrit u - Critical value of t-test for U - component

tstar u - Calculated value of t test statistic for U- component

pval u - P-value calculated for U -component

tcrit v - Critical value of t-test for V - component

tstar v - Calculated value of t test statistic for V -component

pval v - P-value calculated for V -component

Note:

In the following tables, a height followed by all zeros in the same row indicates there were no matches found at that height, therefore, no statistics were calculated for that height. A height followed by an RMSVD value, then a dummy value of 2 for the (r) and (r^2) values, indicates there were only 1 or 2 matches between the u and v components at this height. The RMSVD value can be calculated; however, for only 1 match, the (r) value would be infinite, for 2 matches, the (r) value would be 1. Therefore, for these cases, the dummy value of 2 was assigned to the (r) and (r^2) values. However, these values of 2 were not plotted in the graphical plots in Chapters 4, 5, and 6.

Statistical data for the comparison between the wind profiler data and the modified VAD wind data

Fall 1995

Vandenberg - Fall 1995: Profiler / VAD (modified) (Range 28.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	3.019	0.778	0.414	0.605	0.172	3.182	2.143	0.061	3.182	0.788	0.244
750	4.43	-0.764	0.762	0.583	0.581	-3.182	-2.048	0.066	3.182	2.041	0.067
1000	7.575	-0.371	0.769	0.137	0.592	-2.021	-2.523	0.008	2.021	7.616	0
1250	8.078	-0.309	0.503	0.096	0.253	-2.028	-1.952	0.029	2.028	3.489	0.001
1500	3.859	2	2	2	2	0	0	0	0	0	0
1750	0	0	0	0	0	0	0	0	0	0	0
2000	13.121	0.114	0.106	0.013	0.011	2.12	0.46	0.326	2.12	0.425	0.338
2250	13.179	0.311	-0.651	0.097	0.424	2.12	1.308	0.105	-2.12	-3.429	0.002
2500	7.391	0.654	0.301	0.428	0.09	2.048	4.574	0	2.048	1.669	0.053
2750	7.01	0.36	0.319	0.129	0.102	2.045	2.077	0.023	2.045	1.812	0.04
3000	7.02	0.226	0.26	0.051	0.067	2.048	1.227	0.115	2.048	1.423	0.083
3250	8.326	-0.515	0.293	0.265	0.086	-2.101	-2.551	0.01	2.101	1.3	0.105
3500	8.471	-0.531	0.175	0.282	0.031	-2.101	-2.66	0.008	2.101	0.754	0.23
3750	8.647	-0.222	0.193	0.049	0.037	-2.052	-1.185	0.123	2.052	1.024	0.157
4000	8.415	-0.252	0.094	0.064	0.009	-2.101	-1.106	0.142	2.101	0.4	0.347
4250	7.02	-0.144	-0.024	0.021	0.001	-2.06	-0.728	0.237	-2.06	-0.118	0.454
4500	3.311	2	2	2	2	0	0	0	0	0	0
4750	0	0	0	0	0	0	0	0	0	0	0
5000	0	0	0	0	0	0	0	0	0	0	0
5250	0	0	0	0	0	0	0	0	0	0	0
5500	0	0	0	0	0	0	0	0	0	0	0
5750	0	0	0	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0	0	0	0

Avg. rmsvd = 7.430 Avg. (r^2) u = 0.202 Avg (r^2) v = 0.175

Vandenberg - Fall 1995: Profiler / VAD (modified) (Range 26.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	3.019	0.778	0.414	0.605	0.172	3.182	2.143	0.061	3.182	0.788	0.244
750	4.43	-0.764	0.762	0.583	0.581	-3.182	-2.048	0.066	3.182	2.041	0.067
1000	7.575	-0.371	0.769	0.137	0.592	-2.021	-2.523	0.008	2.021	7.616	0
1250	8.078	-0.309	0.503	0.096	0.253	-2.028	-1.952	0.029	2.028	3.489	0.001
1500	3.859	2	2	2	2	0	0	0	0	0	0
1750	11.161	0.218	-0.178	0.048	0.032	2.048	1.185	0.123	-2.048	-0.957	0.173
2000	13.121	0.114	0.106	0.013	0.011	2.12	0.46	0.326	2.12	0.425	0.338
2250	13.179	0.311	-0.651	0.097	0.424	2.12	1.308	0.105	-2.12	-3.429	0.002
2500	7.391	0.654	0.301	0.428	0.09	2.048	4.574	0	2.048	1.669	0.053
2750	7.01	0.36	0.319	0.129	0.102	2.045	2.077	0.023	2.045	1.812	0.04
3000	7.02	0.226	0.26	0.051	0.067	2.048	1.227	0.115	2.048	1.423	0.083
3250	8.326	-0.515	0.293	0.265	0.086	-2.101	-2.551	0.01	2.101	1.3	0.105
3500	8.471	-0.531	0.175	0.282	0.031	-2.101	-2.66	0.008	2.101	0.754	0.23
3750	8.647	-0.222	0.193	0.049	0.037	-2.052	-1.185	0.123	2.052	1.024	0.157
4000	8.415	-0.252	0.094	0.064	0.009	-2.101	-1.106	0.142	2.101	0.4	0.347
4250	7.02	-0.144	-0.024	0.021	0.001	-2.06	-0.728	0.237	-2.06	-0.118	0.454
4500	3.311	2	2	2	2	0	0	0	0	0	0
4750	0	0	0	0	0	0	0	0	0	0	0
5000	0	0	0	0	0	0	0	0	0	0	0
5250	0	0	0	0	0	0	0	0	0	0	0
5500	0	0	0	0	0	0	0	0	0	0	0
5750	0	0	0	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0	0	0	0

Avg. rmsvd = 7.649 Avg. (r^2) u = 0.191 Avg (r^2) v = 0.166

Vandenberg - Fall 1995: Profiler / VAD (modified) (Range 24.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	3.019	0.778	0.414	0.605	0.172	3.182	2.143	0.061	3.182	0.788	0.244
750	4.43	-0.764	0.762	0.583	0.581	-3.182	-2.048	0.066	3.182	2.041	0.067
1000	7.575	-0.371	0.769	0.137	0.592	-2.021	-2.523	0.008	2.021	7.616	0
1250	8.093	-0.324	0.541	0.105	0.292	-2.032	-1.994	0.027	2.032	3.748	0
1500	3.859	2	2	2	2	0	0	0	0	0	0
1750	11.161	0.218	-0.178	0.048	0.032	2.048	1.185	0.123	-2.048	-0.957	0.173
2000	10.373	0.37	0.402	0.137	0.161	2.06	1.99	0.029	2.06	2.193	0.019
2250	9.877	0.424	0.134	0.18	0.018	2.06	2.341	0.014	2.06	0.675	0.253
2500	7.391	0.654	0.301	0.428	0.09	2.048	4.574	0	2.048	1.669	0.053
2750	7.01	0.36	0.319	0.129	0.102	2.045	2.077	0.023	2.045	1.812	0.04
3000	7.02	0.226	0.26	0.051	0.067	2.048	1.227	0.115	2.048	1.423	0.083
3250	8.326	-0.515	0.293	0.265	0.086	-2.101	-2.551	0.01	2.101	1.3	0.105
3500	8.471	-0.531	0.175	0.282	0.031	-2.101	-2.66	0.008	2.101	0.754	0.23
3750	8.647	-0.222	0.193	0.049	0.037	-2.052	-1.185	0.123	2.052	1.024	0.157
4000	8.415	-0.252	0.094	0.064	0.009	-2.101	-1.106	0.142	2.101	0.4	0.347
4250	7.02	-0.144	-0.024	0.021	0.001	-2.06	-0.728	0.237	-2.06	-0.118	0.454
4500	3.311	2	2	2	2	0	0	0	0	0	0
4750	0	0	0	0	0	0	0	0	0	0	0
5000	0	0	0	0	0	0	0	0	0	0	0
5250	0	0	0	0	0	0	0	0	0	0	0
5500	0	0	0	0	0	0	0	0	0	0	0
5750	0	0	0	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0	0	0	0

Avg. rmsvd = 7.294 Avg. (r^2) u = 0.206 Avg (r^2) v = 0.151

Vandenberg - Fall 1995: Profiler / VAD (modified) (Range 22.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	3.019	0.778	0.414	0.605	0.172	3.182	2.143	0.061	3.182	0.788	0.244
750	4.43	-0.764	0.762	0.583	0.581	-3.182	-2.048	0.066	3.182	2.041	0.067
1000	7.575	-0.371	0.769	0.137	0.592	-2.021	-2.523	0.008	2.021	7.616	0
1250	0	0	0	0	0	0	0	0	0	0	0
1500	0	0	0	0	0	0	0	0	0	0	0
1750	11.161	0.218	-0.178	0.048	0.032	2.048	1.185	0.123	-2.048	-0.957	0.173
2000	10.373	0.37	0.402	0.137	0.161	2.06	1.99	0.029	2.06	2.193	0.019
2250	9.877	0.424	0.134	0.18	0.018	2.06	2.341	0.014	2.06	0.675	0.253
2500	7.391	0.654	0.301	0.428	0.09	2.048	4.574	0	2.048	1.669	0.053
2750	7.01	0.36	0.319	0.129	0.102	2.045	2.077	0.023	2.045	1.812	0.04
3000	7.02	0.226	0.26	0.051	0.067	2.048	1.227	0.115	2.048	1.423	0.083
3250	8.326	-0.515	0.293	0.265	0.086	-2.101	-2.551	0.01	2.101	1.3	0.105
3500	8.471	-0.531	0.175	0.282	0.031	-2.101	-2.66	0.008	2.101	0.754	0.23
3750	8.647	-0.222	0.193	0.049	0.037	-2.052	-1.185	0.123	2.052	1.024	0.157
4000	8.415	-0.252	0.094	0.064	0.009	-2.101	-1.106	0.142	2.101	0.4	0.347
4250	7.02	-0.144	-0.024	0.021	0.001	-2.06	-0.728	0.237	-2.06	-0.118	0.454
4500	3.311	2	2	2	2	0	0	0	0	0	0
4750	0	0	0	0	0	0	0	0	0	0	0
5000	0	0	0	0	0	0	0	0	0	0	0
5250	0	0	0	0	0	0	0	0	0	0	0
5500	0	0	0	0	0	0	0	0	0	0	0
5750	0	0	0	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0	0	0	0

Avg. rmsvd = 7.470 Avg. (r^2) u = 0.213 Avg (r^2) v = 0.141

Vandenberg - Fall 1995: Profiler / VAD (modified) (Range 20.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	3.019	0.778	0.414	0.605	0.172	3.182	2.143	0.061	3.182	0.788	0.244
750	4.43	-0.764	0.762	0.583	0.581	-3.182	-2.048	0.066	3.182	2.041	0.067
1000	7.575	-0.371	0.769	0.137	0.592	-2.021	-2.523	0.008	2.021	7.616	0
1250	0	0	0	0	0	0	0	0	0	0	0
1500	10.215	-0.006	0.321	0	0.103	-2.06	-0.03	0.488	2.06	1.692	0.052
1750	12.141	0.345	-0.485	0.119	0.236	2.074	1.722	0.05	-2.074	-2.604	0.008
2000	10.373	0.37	0.402	0.137	0.161	2.06	1.99	0.029	2.06	2.193	0.019
2250	9.877	0.424	0.134	0.18	0.018	2.06	2.341	0.014	2.06	0.675	0.253
2500	7.391	0.654	0.301	0.428	0.09	2.048	4.574	0	2.048	1.669	0.053
2750	7.01	0.36	0.319	0.129	0.102	2.045	2.077	0.023	2.045	1.812	0.04
3000	7.02	0.226	0.26	0.051	0.067	2.048	1.227	0.115	2.048	1.423	0.083
3250	8.326	-0.515	0.293	0.265	0.086	-2.101	-2.551	0.01	2.101	1.3	0.105
3500	8.471	-0.531	0.175	0.282	0.031	-2.101	-2.66	0.008	2.101	0.754	0.23
3750	8.647	-0.222	0.193	0.049	0.037	-2.052	-1.185	0.123	2.052	1.024	0.157
4000	8.415	-0.252	0.094	0.064	0.009	-2.101	-1.106	0.142	2.101	0.4	0.347
4250	7.02	-0.144	-0.024	0.021	0.001	-2.06	-0.728	0.237	-2.06	-0.118	0.454
4500	3.311	2	2	2	2	0	0	0	0	0	0
4750	0	0	0	0	0	0	0	0	0	0	0
5000	0	0	0	0	0	0	0	0	0	0	0
5250	0	0	0	0	0	0	0	0	0	0	0
5500	0	0	0	0	0	0	0	0	0	0	0
5750	0	0	0	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0	0	0	0

Avg. rmsvd = 7.703 Avg. (r^2) u = 0.203 Avg (r^2) v = 0.152

Vandenberg - Fall 1995: Profiler / VAD (modified) (Range 32.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	3.019	0.778	0.414	0.605	0.172	3.182	2.143	0.061	3.182	0.788	0.244
750	4.43	-0.764	0.762	0.583	0.581	-3.182	-2.048	0.066	3.182	2.041	0.067
1000	6.5	0.991	-0.725	0.983	0.526	12.706	7.506	0.042	-12.706	-1.053	0.242
1250	8.078	-0.309	0.503	0.096	0.253	-2.028	-1.952	0.029	2.028	3.489	0.001
1500	3.859	2	2	2	2	0	0	0	0	0	0
1750	7.024	0	-0.569	0	0.324	12.706	0	0.5	-12.706	-0.693	0.307
2000	13.121	0.114	0.106	0.013	0.011	2.12	0.46	0.326	2.12	0.425	0.338
2250	13.179	0.311	-0.651	0.097	0.424	2.12	1.308	0.105	-2.12	-3.429	0.002
2500	11.892	0.339	-0.374	0.115	0.14	2.12	1.441	0.084	-2.12	-1.613	0.063
2750	7.01	0.36	0.319	0.129	0.102	2.045	2.077	0.023	2.045	1.812	0.04
3000	7.02	0.226	0.26	0.051	0.067	2.048	1.227	0.115	2.048	1.423	0.083
3250	8.326	-0.515	0.293	0.265	0.086	-2.101	-2.551	0.01	2.101	1.3	0.105
3500	8.471	-0.531	0.175	0.282	0.031	-2.101	-2.66	0.008	2.101	0.754	0.23
3750	8.647	-0.222	0.193	0.049	0.037	-2.052	-1.185	0.123	2.052	1.024	0.157
4000	8.415	-0.252	0.094	0.064	0.009	-2.101	-1.106	0.142	2.101	0.4	0.347
4250	7.02	-0.144	-0.024	0.021	0.001	-2.06	-0.728	0.237	-2.06	-0.118	0.454
4500	3.311	2	2	2	2	0	0	0	0	0	0
4750	0	0	0	0	0	0	0	0	0	0	0
5000	0	0	0	0	0	0	0	0	0	0	0
5250	0	0	0	0	0	0	0	0	0	0	0
5500	0	0	0	0	0	0	0	0	0	0	0
5750	0	0	0	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0	0	0	0

Avg. rmsvd = 7.607   Avg. (r^2) u = 0.224   Avg (r^2) v = 0.184

Winter 1996

Vandenberg - Winter 1996: Profiler / VAD (modified) (Range 28.0 km)

Hgt(m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	17.853	0.052	0.591	0.003	0.35	1.969	0.835	0.202	1.969	11.753	0
750	14.548	0.57	0.623	0.325	0.388	1.969	11.197	0	1.969	12.848	0
1000	14.151	0.598	0.711	0.358	0.505	1.968	12.631	0	1.968	17.093	0
1250	13.019	0.613	0.74	0.376	0.548	1.971	11.184	0	1.971	15.875	0
1500	8.646	0.79	0.9	0.624	0.809	1.977	15.145	0	1.977	24.215	0
1750	7.906	0.877	0.913	0.768	0.833	1.979	20.281	0	1.979	24.888	0
2000	15.912	0.792	0.17	0.627	0.029	1.973	17.248	0	1.973	2.298	0.011
2250	16.71	0.769	0.569	0.591	0.324	1.974	15.798	0	1.974	9.101	0
2500	18.585	0.841	0.417	0.708	0.174	1.978	17.963	0	1.978	5.287	0
2750	14.435	0.721	0.666	0.52	0.444	1.981	11.055	0	1.981	9.501	0
3000	13.054	0.695	0.74	0.483	0.547	1.98	10.537	0	1.98	11.999	0
3250	18.215	0.747	0.462	0.557	0.213	1.985	10.937	0	1.985	5.075	0
3500	18.9	0.683	0.448	0.466	0.2	1.985	9.108	0	1.985	4.879	0
3750	10.807	0.541	0.867	0.293	0.752	1.986	6.175	0	1.986	16.696	0
4000	7.624	0.772	0.888	0.596	0.789	1.987	11.457	0	1.987	18.216	0
4250	7.953	0.73	0.893	0.533	0.798	1.989	9.8	0	1.989	18.206	0
4500	6.918	0.78	0.931	0.609	0.867	1.989	11.292	0	1.989	23.126	0
4750	14.817	0.782	0.595	0.612	0.354	1.989	11.379	0	1.989	6.698	0
5000	14.538	0.748	0.647	0.559	0.833	1.989	10.205	0	1.989	7.684	0
5250	8.923	0.673	0.928	0.453	0.213	1.986	8.722	0	1.986	23.923	0
5500	8.576	0.761	0.94	0.58	0.354	1.986	11.326	0	1.986	26.494	0
5750	9.005	0.865	0.831	0.748	0.833	1.985	16.77	0	1.985	14.581	0
6000	8.838	0.887	0.835	0.787	0.213	1.986	18.517	0	1.986	14.647	0

Avg. rmsvd = 12.606 Avg. (r^2) u = 0.529 Avg (r^2) v = 0.494

Vandenberg - Winter 1996: Profiler / VAD (modified) (Range 26.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	17.853	0.052	0.591	0.003	0.35	1.969	0.835	0.202	1.969	11.753	0
750	14.548	0.57	0.623	0.325	0.388	1.969	11.197	0	1.969	12.848	0
1000	14.151	0.598	0.711	0.358	0.505	1.968	12.631	0	1.968	17.093	0
1250	13.019	0.613	0.74	0.376	0.548	1.971	11.184	0	1.971	15.875	0
1500	8.646	0.79	0.9	0.624	0.809	1.977	15.145	0	1.977	24.215	0
1750	11.779	0.872	0.782	0.76	0.611	1.972	25.016	0	1.972	17.642	0
2000	15.912	0.792	0.17	0.627	0.029	1.973	17.248	0	1.973	2.298	0.011
2250	16.71	0.769	0.569	0.591	0.324	1.974	15.798	0	1.974	9.101	0
2500	18.585	0.841	0.417	0.708	0.174	1.978	17.963	0	1.978	5.287	0
2750	13.784	0.705	0.73	0.497	0.533	1.979	11.168	0	1.979	11.984	0
3000	13.054	0.695	0.74	0.483	0.547	1.98	10.537	0	1.98	11.999	0
3250	18.215	0.747	0.462	0.557	0.213	1.985	10.937	0	1.985	5.075	0
3500	18.9	0.683	0.448	0.466	0.2	1.985	9.108	0	1.985	4.879	0
3750	10.807	0.541	0.867	0.293	0.752	1.986	6.175	0	1.986	16.696	0
4000	6.871	0.837	0.897	0.7	0.805	1.988	14.176	0	1.988	18.817	0
4250	7.953	0.73	0.893	0.533	0.798	1.989	9.8	0	1.989	18.206	0
4500	6.918	0.78	0.931	0.609	0.867	1.989	11.292	0	1.989	23.126	0
4750	14.817	0.782	0.595	0.612	0.354	1.989	11.379	0	1.989	6.698	0
5000	14.538	0.748	0.647	0.559	0.611	1.989	10.205	0	1.989	7.684	0
5250	8.923	0.673	0.928	0.453	0.213	1.986	8.722	0	1.986	23.923	0
5500	8.576	0.761	0.94	0.58	0.354	1.986	11.326	0	1.986	26.494	0
5750	8.677	0.875	0.855	0.765	0.611	1.983	18.24	0	1.983	16.615	0
6000	9.099	0.878	0.862	0.772	0.213	1.983	18.839	0	1.983	17.457	0

Avg. rmsvd = 12.710 Avg. (r^2) u = 0.533 Avg (r^2) v = 0.470

Vandenberg - Winter 1996: Profiler / VAD (modified) (Range 24.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	17.853	0.052	0.591	0.003	0.35	1.969	0.835	0.202	1.969	11.753	0
750	14.548	0.57	0.623	0.325	0.388	1.969	11.197	0	1.969	12.848	0
1000	14.151	0.598	0.711	0.358	0.505	1.968	12.631	0	1.968	17.093	0
1250	15.57	0.699	0.594	0.489	0.353	1.971	14.116	0	1.971	10.657	0
1500	8.646	0.79	0.9	0.624	0.809	1.977	15.145	0	1.977	24.215	0
1750	11.779	0.872	0.782	0.76	0.611	1.972	25.016	0	1.972	17.642	0
2000	18.368	0.869	-0.23	0.756	0.053	1.976	21.687	0	-1.976	-2.911	0.002
2250	19.296	0.845	0.347	0.713	0.12	1.976	19.32	0	1.976	4.532	0
2500	18.585	0.841	0.417	0.708	0.174	1.978	17.963	0	1.978	5.287	0
2750	13.784	0.705	0.73	0.497	0.533	1.979	11.168	0	1.979	11.984	0
3000	13.054	0.695	0.74	0.483	0.547	1.98	10.537	0	1.98	11.999	0
3250	18.215	0.747	0.462	0.557	0.213	1.985	10.937	0	1.985	5.075	0
3500	18.9	0.683	0.448	0.466	0.2	1.985	9.108	0	1.985	4.879	0
3750	10.203	0.663	0.887	0.44	0.786	1.986	8.586	0	1.986	18.593	0
4000	6.871	0.837	0.897	0.7	0.805	1.988	14.176	0	1.988	18.817	0
4250	7.953	0.73	0.893	0.533	0.798	1.989	9.8	0	1.989	18.206	0
4500	6.918	0.78	0.931	0.609	0.867	1.989	11.292	0	1.989	23.126	0
4750	14.817	0.782	0.595	0.612	0.354	1.989	11.379	0	1.989	6.698	0
5000	14.538	0.748	0.647	0.559	0.611	1.989	10.205	0	1.989	7.684	0
5250	8.923	0.673	0.928	0.453	0.213	1.986	8.722	0	1.986	23.923	0
5500	7.486	0.845	0.922	0.715	0.354	1.984	15.833	0	1.984	23.73	0
5750	8.677	0.875	0.855	0.765	0.611	1.983	18.24	0	1.983	16.615	0
6000	9.099	0.878	0.862	0.772	0.213	1.983	18.839	0	1.983	17.457	0

Avg. rmsvd = 12.967 Avg. (r^2) u = 0.561 Avg (r^2) v = 0.455

Vandenberg - Winter 1996: Profiler / VAD (modified) (Range 22.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	17.853	0.052	0.591	0.003	0.35	1.969	0.835	0.202	1.969	11.753	0
750	14.548	0.57	0.623	0.325	0.388	1.969	11.197	0	1.969	12.848	0
1000	14.151	0.598	0.711	0.358	0.505	1.968	12.631	0	1.968	17.093	0
1250	15.155	0.82	0.671	0.673	0.45	1.976	17.44	0	1.976	11.002	0
1500	11.211	0.838	0.789	0.702	0.623	1.975	19.049	0	1.975	15.953	0
1750	11.779	0.872	0.782	0.76	0.611	1.972	25.016	0	1.972	17.642	0
2000	18.368	0.869	-0.23	0.756	0.053	1.976	21.687	0	-1.976	-2.911	0.002
2250	19.296	0.845	0.347	0.713	0.12	1.976	19.32	0	1.976	4.532	0
2500	18.414	0.806	0.476	0.65	0.226	1.978	15.832	0	1.978	6.282	0
2750	13.784	0.705	0.73	0.497	0.533	1.979	11.168	0	1.979	11.984	0
3000	13.054	0.695	0.74	0.483	0.547	1.98	10.537	0	1.98	11.999	0
3250	14.24	0.741	0.704	0.548	0.495	1.986	10.514	0	1.986	9.446	0
3500	14.767	0.723	0.703	0.523	0.494	1.986	9.997	0	1.986	9.424	0
3750	10.203	0.663	0.887	0.44	0.786	1.986	8.586	0	1.986	18.593	0
4000	6.871	0.837	0.897	0.7	0.805	1.988	14.176	0	1.988	18.817	0
4250	7.953	0.73	0.893	0.533	0.798	1.989	9.8	0	1.989	18.206	0
4500	6.918	0.78	0.931	0.609	0.867	1.989	11.292	0	1.989	23.126	0
4750	14.817	0.782	0.595	0.612	0.354	1.989	11.379	0	1.989	6.698	0
5000	14.538	0.748	0.647	0.559	0.611	1.989	10.205	0	1.989	7.684	0
5250	8.6	0.694	0.924	0.481	0.495	1.988	8.875	0	1.988	22.347	0
5500	7.486	0.845	0.922	0.715	0.354	1.984	15.833	0	1.984	23.73	0
5750	8.677	0.875	0.855	0.765	0.611	1.983	18.24	0	1.983	16.615	0
6000	9.099	0.878	0.862	0.772	0.495	1.983	18.839	0	1.983	17.457	0

Avg. rmsvd = 12.686 Avg. (r^2) u = 0.573 Avg (r^2) v = 0.503

Vandenberg - Winter 1996: Profiler / VAD (modified) (Range 20.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	17.853	0.052	0.591	0.003	0.35	1.969	0.835	0.202	1.969	11.753	0
750	14.548	0.57	0.623	0.325	0.388	1.969	11.197	0	1.969	12.848	0
1000	14.151	0.598	0.711	0.358	0.505	1.968	12.631	0	1.968	17.093	0
1250	15.155	0.82	0.671	0.673	0.45	1.976	17.44	0	1.976	11.002	0
1500	12.246	0.798	0.75	0.637	0.562	1.97	19.99	0	1.97	17.115	0
1750	15.118	0.884	0.563	0.782	0.317	1.975	24.079	0	1.975	8.664	0
2000	18.368	0.869	-0.23	0.756	0.053	1.976	21.687	0	-1.976	-2.911	0.002
2250	19.296	0.845	0.347	0.713	0.12	1.976	19.32	0	1.976	4.532	0
2500	18.414	0.806	0.476	0.65	0.226	1.978	15.832	0	1.978	6.282	0
2750	13.784	0.705	0.73	0.497	0.533	1.979	11.168	0	1.979	11.984	0
3000	13.032	0.704	0.723	0.496	0.522	1.98	10.917	0	1.98	11.505	0
3250	14.24	0.741	0.704	0.548	0.495	1.986	10.514	0	1.986	9.446	0
3500	14.767	0.723	0.703	0.523	0.494	1.986	9.997	0	1.986	9.424	0
3750	10.203	0.663	0.887	0.44	0.786	1.986	8.586	0	1.986	18.593	0
4000	6.871	0.837	0.897	0.7	0.805	1.988	14.176	0	1.988	18.817	0
4250	7.953	0.73	0.893	0.533	0.798	1.989	9.8	0	1.989	18.206	0
4500	7.06	0.785	0.892	0.616	0.795	1.988	11.684	0	1.988	18.148	0
4750	7.876	0.735	0.887	0.54	0.787	1.988	10.105	0	1.988	17.948	0
5000	8.965	0.697	0.86	0.486	0.317	1.988	9.073	0	1.988	15.712	0
5250	8.6	0.694	0.924	0.481	0.495	1.988	8.875	0	1.988	22.347	0
5500	7.486	0.845	0.922	0.715	0.787	1.984	15.833	0	1.984	23.73	0
5750	8.677	0.875	0.855	0.765	0.317	1.983	18.24	0	1.983	16.615	0
6000	9.099	0.878	0.862	0.772	0.495	1.983	18.839	0	1.983	17.457	0

Avg. rmsvd = 12.337 Avg. (r^2) u = 0.566 Avg (r^2) v = 0.496

Vandenberg - Winter 1996: Profiler / VAD (modified) (Range 32.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	17.853	0.052	0.591	0.003	0.35	1.969	0.835	0.202	1.969	11.753	0
750	14.548	0.57	0.623	0.325	0.388	1.969	11.197	0	1.969	12.848	0
1000	12.671	0.721	0.672	0.521	0.452	1.975	13.221	0	1.975	11.517	0
1250	13.019	0.613	0.74	0.376	0.548	1.971	11.184	0	1.971	15.875	0
1500	8.646	0.79	0.9	0.624	0.809	1.977	15.145	0	1.977	24.215	0
1750	8.757	0.795	0.91	0.632	0.827	1.98	14.303	0	1.98	23.884	0
2000	15.912	0.792	0.17	0.627	0.029	1.973	17.248	0	1.973	2.298	0.011
2250	16.71	0.769	0.569	0.591	0.324	1.974	15.798	0	1.974	9.101	0
2500	16.768	0.738	0.581	0.544	0.337	1.975	13.555	0	1.975	8.852	0
2750	14.435	0.721	0.666	0.52	0.444	1.981	11.055	0	1.981	9.501	0
3000	17.69	0.673	0.564	0.453	0.318	1.983	9.37	0	1.983	7.024	0
3250	18.215	0.747	0.462	0.557	0.213	1.985	10.937	0	1.985	5.075	0
3500	18.9	0.683	0.448	0.466	0.2	1.985	9.108	0	1.985	4.879	0
3750	10.807	0.541	0.867	0.293	0.752	1.986	6.175	0	1.986	16.696	0
4000	7.624	0.772	0.888	0.596	0.789	1.987	11.457	0	1.987	18.216	0
4250	9.362	0.603	0.844	0.363	0.712	1.988	7.048	0	1.988	14.656	0
4500	13.515	0.599	0.633	0.359	0.4	1.987	7.015	0	1.987	7.666	0
4750	14.817	0.782	0.595	0.612	0.354	1.989	11.379	0	1.989	6.698	0
5000	14.538	0.748	0.647	0.559	0.827	1.989	10.205	0	1.989	7.684	0
5250	8.923	0.673	0.928	0.453	0.213	1.986	8.722	0	1.986	23.923	0
5500	8.576	0.761	0.94	0.58	0.354	1.986	11.326	0	1.986	26.494	0
5750	9.005	0.865	0.831	0.748	0.827	1.985	16.77	0	1.985	14.581	0
6000	8.838	0.887	0.835	0.787	0.213	1.986	18.517	0	1.986	14.647	0

Avg. rmsvd = 13.049 Avg. (r^2) u = 0.504 Avg (r^2) v = 0.464

Spring 1996

Vandenberg - Spring 1996: Profiler / VAD (modified) Range 28.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tcrit v	pval u	tcrit v	tstar v	pval v
500	14.318	0.6	0.436	0.36	0.19	1.995	6.191	0	1.995	3.991	0
750	16.904	0.533	0.19	0.284	0.036	1.995	5.198	0	1.995	1.599	0.057
1000	20.028	0.359	-0.042	0.129	0.002	1.966	7.484	0	-1.966	-0.821	0.206
1250	19.746	0.356	0.04	0.127	0.002	1.967	7.048	0	1.967	0.734	0.232
1500	22.499	0.901	-0.336	0.812	0.113	2.032	12.128	0	-2.032	-2.082	0.022
1750	26.484	0.89	-0.557	0.792	0.31	2.026	11.866	0	-2.026	-4.077	0
2000	28.224	0.517	0.027	0.268	0.001	1.966	11.939	0	1.966	0.534	0.297
2250	29.627	0.503	-0.399	0.253	0.159	1.966	11.519	0	-1.966	-8.603	0
2500	28.687	0.489	-0.202	0.24	0.041	1.968	9.85	0	-1.968	-3.621	0
2750	25.9	0.476	-0.112	0.227	0.012	1.969	8.959	0	-1.969	-1.859	0.032
3000	26.344	0.511	-0.114	0.261	0.013	1.97	9.261	0	-1.97	-1.782	0.038
3250	26.462	0.489	-0.124	0.239	0.015	1.971	8.209	0	-1.971	-1.835	0.034
3500	27.77	0.481	-0.214	0.232	0.046	1.971	8.051	0	-1.971	-3.212	0.001
3750	27.232	0.481	-0.092	0.231	0.008	1.972	7.731	0	-1.972	-1.299	0.098
4000	27.408	0.449	-0.058	0.201	0.003	1.973	6.809	0	-1.973	-0.793	0.215
4250	26.374	0.544	0.058	0.296	0.003	1.972	9.166	0	1.972	0.824	0.206
4500	24.148	0.696	0.135	0.485	0.018	1.977	11.565	0	1.977	1.626	0.053
4750	26.736	0.659	-0.154	0.435	0.024	1.98	9.684	0	-1.98	-1.725	0.043
5000	26.463	0.665	-0.145	0.442	0.31	1.978	10.148	0	-1.978	-1.669	0.049
5250	26.376	0.777	-0.13	0.604	0.015	1.987	11.658	0	-1.987	-1.239	0.109
5500	29.732	0.592	-0.244	0.351	0.024	1.984	7.275	0	-1.984	-2.494	0.007
5750	29.889	0.691	-0.088	0.477	0.31	1.995	7.881	0	-1.995	-0.73	0.234
6000	25.539	0.833	0.342	0.694	0.015	2.026	9.162	0	2.026	2.21	0.017

Avg. rmsvd = 25.343 Avg. (r^2) u = 0.367 Avg (r^2) v = 0.073

Vandenberg - Spring 1996: Profiler / VAD (modified) Range 26.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	14.318	0.6	0.436	0.36	0.19	1.995	6.191	0	1.995	3.991	0
750	16.904	0.533	0.19	0.284	0.036	1.995	5.198	0	1.995	1.599	0.057
1000	20.028	0.359	-0.042	0.129	0.002	1.966	7.484	0	-1.966	-0.821	0.206
1250	19.746	0.356	0.04	0.127	0.002	1.967	7.048	0	1.967	0.734	0.232
1500	22.499	0.901	-0.336	0.812	0.113	2.032	12.128	0	-2.032	-2.082	0.022
1750	25.76	0.544	-0.296	0.296	0.088	1.966	12.766	0	-1.966	-6.103	0
2000	28.224	0.517	0.027	0.268	0.001	1.966	11.939	0	1.966	0.534	0.297
2250	29.627	0.503	-0.399	0.253	0.159	1.966	11.519	0	-1.966	-8.603	0
2500	28.687	0.489	-0.202	0.24	0.041	1.968	9.85	0	-1.968	-3.621	0
2750	25.806	0.481	-0.111	0.231	0.012	1.969	9.118	0	-1.969	-1.851	0.033
3000	26.344	0.511	-0.114	0.261	0.013	1.97	9.261	0	-1.97	-1.782	0.038
3250	26.462	0.489	-0.124	0.239	0.015	1.971	8.209	0	-1.971	-1.835	0.034
3500	27.77	0.481	-0.214	0.232	0.046	1.971	8.051	0	-1.971	-3.212	0.001
3750	27.232	0.481	-0.092	0.231	0.008	1.972	7.731	0	-1.972	-1.299	0.098
4000	27.475	0.435	-0.058	0.19	0.003	1.973	6.542	0	-1.973	-0.785	0.217
4250	26.374	0.544	0.058	0.296	0.003	1.972	9.166	0	1.972	0.824	0.206
4500	24.148	0.696	0.135	0.485	0.018	1.977	11.565	0	1.977	1.626	0.053
4750	26.736	0.659	-0.154	0.435	0.024	1.98	9.684	0	-1.98	-1.725	0.043
5000	26.463	0.665	-0.145	0.442	0.088	1.978	10.148	0	-1.978	-1.669	0.049
5250	26.376	0.777	-0.13	0.604	0.015	1.987	11.658	0	-1.987	-1.239	0.109
5500	29.732	0.592	-0.244	0.351	0.024	1.984	7.275	0	-1.984	-2.494	0.007
5750	29.889	0.691	-0.088	0.477	0.088	1.995	7.881	0	-1.995	-0.73	0.234
6000	25.232	0.874	0.305	0.764	0.015	2.024	11.097	0	2.024	1.973	0.028

Avg. rmsvd = 25.297 Avg. (r^2) u = 0.348 Avg (r^2) v = 0.044

Vandenberg - Spring 1996: Profiler / VAD (modified) Range 24.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	14.318	0.6	0.436	0.36	0.19	1.995	6.191	0	1.995	3.991	0
750	16.904	0.533	0.19	0.284	0.036	1.995	5.198	0	1.995	1.599	0.057
1000	20.028	0.359	-0.042	0.129	0.002	1.966	7.484	0	-1.966	-0.821	0.206
1250	20.892	0.393	-0.011	0.154	0	1.967	8.012	0	-1.967	-0.212	0.416
1500	22.499	0.901	-0.336	0.812	0.113	2.032	12.128	0	-2.032	-2.082	0.022
1750	25.76	0.544	-0.296	0.296	0.088	1.966	12.766	0	-1.966	-6.103	0
2000	26.351	0.54	0.053	0.292	0.003	1.967	11.558	0	1.967	0.95	0.171
2250	27.953	0.47	-0.383	0.221	0.146	1.967	9.599	0	-1.967	-7.465	0
2500	28.687	0.489	-0.202	0.24	0.041	1.968	9.85	0	-1.968	-3.621	0
2750	25.806	0.481	-0.111	0.231	0.012	1.969	9.118	0	-1.969	-1.851	0.033
3000	26.344	0.511	-0.114	0.261	0.013	1.97	9.261	0	-1.97	-1.782	0.038
3250	26.462	0.489	-0.124	0.239	0.015	1.971	8.209	0	-1.971	-1.835	0.034
3500	27.77	0.481	-0.214	0.232	0.046	1.971	8.051	0	-1.971	-3.212	0.001
3750	27.164	0.464	-0.091	0.215	0.008	1.972	7.411	0	-1.972	-1.298	0.098
4000	27.475	0.435	-0.058	0.19	0.003	1.973	6.542	0	-1.973	-0.785	0.217
4250	26.374	0.544	0.058	0.296	0.003	1.972	9.166	0	1.972	0.824	0.206
4500	24.148	0.696	0.135	0.485	0.018	1.977	11.565	0	1.977	1.626	0.053
4750	26.736	0.659	-0.154	0.435	0.024	1.98	9.684	0	-1.98	-1.725	0.043
5000	26.463	0.665	-0.145	0.442	0.088	1.978	10.148	0	-1.978	-1.669	0.049
5250	26.376	0.777	-0.13	0.604	0.015	1.987	11.658	0	-1.987	-1.239	0.109
5500	29.732	0.592	-0.244	0.351	0.024	1.984	7.275	0	-1.984	-2.494	0.007
5750	29.889	0.691	-0.088	0.477	0.088	1.995	7.881	0	-1.995	-0.73	0.234
6000	25.232	0.874	0.305	0.764	0.015	2.024	11.097	0	2.024	1.973	0.028

Avg. rmsvd = 25.19 Avg. (r^2) u = 0.348 Avg (r^2) v = 0.043

Vandenberg - Spring 1996: Profiler / VAD (modified) Range 22.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	14.318	0.6	0.436	0.36	0.19	1.995	6.191	0	1.995	3.991	0
750	16.904	0.533	0.19	0.284	0.036	1.995	5.198	0	1.995	1.599	0.057
1000	20.028	0.359	-0.042	0.129	0.002	1.966	7.484	0	-1.966	-0.821	0.206
1250	21.812	0.71	0.131	0.503	0.017	2.01	7.048	0	2.01	0.924	0.18
1500	22.274	0.947	-0.269	0.897	0.072	2.014	19.838	0	-2.014	-1.874	0.034
1750	25.76	0.544	-0.296	0.296	0.088	1.966	12.766	0	-1.966	-6.103	0
2000	26.351	0.54	0.053	0.292	0.003	1.967	11.558	0	1.967	0.95	0.171
2250	27.953	0.47	-0.383	0.221	0.146	1.967	9.599	0	-1.967	-7.465	0
2500	27.402	0.492	-0.17	0.242	0.029	1.968	9.854	0	-1.968	-3.004	0.001
2750	25.806	0.481	-0.111	0.231	0.012	1.969	9.118	0	-1.969	-1.851	0.033
3000	26.344	0.511	-0.114	0.261	0.013	1.97	9.261	0	-1.97	-1.782	0.038
3250	26.344	0.495	-0.125	0.245	0.016	1.971	8.374	0	-1.971	-1.849	0.033
3500	27.646	0.488	-0.214	0.238	0.046	1.971	8.232	0	-1.971	-3.231	0.001
3750	27.164	0.464	-0.091	0.215	0.008	1.972	7.411	0	-1.972	-1.298	0.098
4000	27.475	0.435	-0.058	0.19	0.003	1.973	6.542	0	-1.973	-0.785	0.217
4250	26.374	0.544	0.058	0.296	0.003	1.972	9.166	0	1.972	0.824	0.206
4500	24.148	0.696	0.135	0.485	0.018	1.977	11.565	0	1.977	1.626	0.053
4750	26.736	0.659	-0.154	0.435	0.024	1.98	9.684	0	-1.98	-1.725	0.043
5000	26.463	0.665	-0.145	0.442	0.088	1.978	10.148	0	-1.978	-1.669	0.049
5250	26.376	0.777	-0.13	0.604	0.016	1.987	11.658	0	-1.987	-1.239	0.109
5500	29.732	0.592	-0.244	0.351	0.024	1.984	7.275	0	-1.984	-2.494	0.007
5750	29.889	0.691	-0.088	0.477	0.088	1.995	7.881	0	-1.995	-0.73	0.234
6000	25.232	0.874	0.305	0.764	0.016	2.024	11.097	0	2.024	1.973	0.028

Avg. rmsvd = 25.154 Avg. (r^2) u = 0.368 Avg (r^2) v = 0.042

Vandenberg - Spring 1996: Profiler / VAD (modified) Range 20.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	14.318	0.6	0.436	0.36	0.19	1.995	6.191	0	1.995	3.991	0
750	16.904	0.533	0.19	0.284	0.036	1.995	5.198	0	1.995	1.599	0.057
1000	20.028	0.359	-0.042	0.129	0.002	1.966	7.484	0	-1.966	-0.821	0.206
1250	21.812	0.71	0.131	0.503	0.017	2.01	7.048	0	2.01	0.924	0.18
1500	23.1	0.5	-0.162	0.25	0.026	1.966	11.784	0	-1.966	-3.346	0
1750	24.957	0.62	-0.252	0.384	0.064	1.967	14.354	0	-1.967	-4.733	0
2000	26.351	0.54	0.053	0.292	0.003	1.967	11.558	0	1.967	0.95	0.171
2250	27.953	0.47	-0.383	0.221	0.146	1.967	9.599	0	-1.967	-7.465	0
2500	27.402	0.492	-0.17	0.242	0.029	1.968	9.854	0	-1.968	-3.004	0.001
2750	25.806	0.481	-0.111	0.231	0.012	1.969	9.118	0	-1.969	-1.851	0.033
3000	26.028	0.52	-0.111	0.27	0.012	1.97	9.596	0	-1.97	-1.76	0.04
3250	26.344	0.495	-0.125	0.245	0.016	1.971	8.374	0	-1.971	-1.849	0.033
3500	27.646	0.488	-0.214	0.238	0.046	1.971	8.232	0	-1.971	-3.231	0.001
3750	27.164	0.464	-0.091	0.215	0.008	1.972	7.411	0	-1.972	-1.298	0.098
4000	27.475	0.435	-0.058	0.19	0.003	1.973	6.542	0	-1.973	-0.785	0.217
4250	26.374	0.544	0.058	0.296	0.003	1.972	9.166	0	1.972	0.824	0.206
4500	23.986	0.668	0.134	0.446	0.018	1.977	10.777	0	1.977	1.627	0.053
4750	26.736	0.659	-0.154	0.435	0.024	1.98	9.684	0	-1.98	-1.725	0.043
5000	26.463	0.665	-0.145	0.442	0.064	1.978	10.148	0	-1.978	-1.669	0.049
5250	26.376	0.777	-0.13	0.604	0.016	1.987	11.658	0	-1.987	-1.239	0.109
5500	29.732	0.592	-0.244	0.351	0.024	1.984	7.275	0	-1.984	-2.494	0.007
5750	29.889	0.691	-0.088	0.477	0.064	1.995	7.881	0	-1.995	-0.73	0.234
6000	25.232	0.874	0.305	0.764	0.016	2.024	11.097	0	2.024	1.973	0.028

Avg. rmsvd = 25.134 Avg. (r^2) u = 0.342 Avg (r^2) v = 0.036

Vandenberg - Spring 1996: Profiler / VAD (modified) Range 32.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	14.318	0.6	0.436	0.36	0.19	1.995	6.191	0	1.995	3.991	0
750	16.904	0.533	0.19	0.284	0.036	1.995	5.198	0	1.995	1.599	0.057
1000	19.088	0.146	0.223	0.021	0.05	2.056	0.754	0.229	2.056	1.164	0.128
1250	19.746	0.356	0.04	0.127	0.002	1.967	7.048	0	1.967	0.734	0.232
1500	22.499	0.901	-0.336	0.812	0.113	2.032	12.128	0	-2.032	-2.082	0.022
1750	22.452	0.919	-0.326	0.844	0.106	2.045	12.528	0	-2.045	-1.858	0.037
2000	28.224	0.517	0.027	0.268	0.001	1.966	11.939	0	1.966	0.534	0.297
2250	29.627	0.503	-0.399	0.253	0.159	1.966	11.519	0	-1.966	-8.603	0
2500	28.708	0.501	-0.192	0.251	0.037	1.967	11.009	0	-1.967	-3.716	0
2750	25.9	0.476	-0.112	0.227	0.012	1.969	8.959	0	-1.969	-1.859	0.032
3000	26.398	0.507	-0.114	0.257	0.013	1.97	9.154	0	-1.97	-1.78	0.038
3250	26.462	0.489	-0.124	0.239	0.015	1.971	8.209	0	-1.971	-1.835	0.034
3500	27.77	0.481	-0.214	0.232	0.046	1.971	8.051	0	-1.971	-3.212	0.001
3750	27.232	0.481	-0.092	0.231	0.008	1.972	7.731	0	-1.972	-1.299	0.098
4000	27.408	0.449	-0.058	0.201	0.003	1.973	6.809	0	-1.973	-0.793	0.215
4250	26.435	0.57	0.059	0.324	0.003	1.972	9.776	0	1.972	0.831	0.203
4500	24.148	0.696	0.135	0.485	0.018	1.977	11.565	0	1.977	1.626	0.053
4750	26.736	0.659	-0.154	0.435	0.024	1.98	9.684	0	-1.98	-1.725	0.043
5000	26.463	0.665	-0.145	0.442	0.106	1.978	10.148	0	-1.978	-1.669	0.049
5250	26.376	0.777	-0.13	0.604	0.015	1.987	11.658	0	-1.987	-1.239	0.109
5500	29.732	0.592	-0.244	0.351	0.024	1.984	7.275	0	-1.984	-2.494	0.007
5750	29.889	0.691	-0.088	0.477	0.106	1.995	7.881	0	-1.995	-0.73	0.234
6000	25.539	0.833	0.342	0.694	0.015	2.026	9.162	0	2.026	2.21	0.017

Avg. rmsvd = 25.133 Avg. (r^2) u = 0.366 Avg (r^2) v = 0.048

Summer 1996

Vandenberg - Summer 1996: Profiler / VAD (modified) (Range 28.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	8.616	0.468	0.535	0.219	0.287	1.986	5.13	0	1.986	6.144	0
750	12.13	0.358	0.234	0.128	0.055	1.986	3.718	0	1.986	2.336	0.011
1000	8.716	0.445	0.7	0.198	0.49	1.967	9.152	0	1.967	18.049	0
1250	9.687	0.281	0.711	0.079	0.506	1.968	4.994	0	1.968	17.251	0
1500	8.274	0.597	0.856	0.357	0.733	2.035	4.28	0	2.035	9.529	0
1750	5.749	0.39	0.829	0.152	0.688	2.056	2.16	0.02	2.056	7.565	0
2000	14.444	-0.101	-0.028	0.01	0.001	-1.969	-1.608	0.055	-1.969	-0.45	0.327
2250	12.67	-0.153	0.622	0.023	0.387	-1.969	-2.457	0.007	1.969	12.605	0
2500	11.465	0.097	0.776	0.009	0.602	1.971	1.472	0.071	1.971	18.476	0
2750	12.155	0.118	0.719	0.014	0.518	1.971	1.729	0.043	1.971	15.082	0
3000	12.331	0.189	0.686	0.036	0.47	1.972	2.696	0.004	1.972	13.222	0
3250	13.612	0.284	0.6	0.081	0.36	1.973	3.971	0	1.973	10.059	0
3500	13.902	0.351	0.592	0.123	0.35	1.973	4.985	0	1.973	9.761	0
3750	14.334	0.249	0.639	0.062	0.408	1.974	3.331	0.001	1.974	10.767	0
4000	13.447	0.361	0.598	0.131	0.357	1.977	4.617	0	1.977	8.881	0
4250	11.642	0.253	0.387	0.064	0.15	1.977	3.132	0.001	1.977	5.037	0
4500	14.197	0.003	0.293	0	0.086	1.988	0.031	0.488	1.988	2.821	0.003
4750	22.026	-0.429	0.302	0.184	0.091	-2.03	-2.808	0.004	2.03	1.875	0.035
5000	19.991	0.06	0.273	0.004	0.688	2.023	0.376	0.354	2.023	1.77	0.042
5250	20.986	0.334	-0.22	0.111	0.36	2.228	1.119	0.145	-2.228	-0.714	0.246
5500	28.531	-0.531	0.814	0.282	0.091	-2.201	-2.078	0.031	2.201	4.649	0
5750	35.252	-0.895	0.752	0.801	0.688	-2.16	-7.223	0	2.16	4.108	0.001
6000	30.808	-0.792	0.667	0.627	0.36	-2.093	-5.652	0	2.093	3.903	0

Avg. rmsvd = 15.433 Avg. (r^2) u = 0.161 Avg (r^2) v = 0.379

Vandenberg - Summer 1996: Profiler / VAD (modified) (Range 26.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	8.616	0.468	0.535	0.219	0.287	1.986	5.13	0	1.986	6.144	0
750	12.13	0.358	0.234	0.128	0.055	1.986	3.718	0	1.986	2.336	0.011
1000	8.716	0.445	0.7	0.198	0.49	1.967	9.152	0	1.967	18.049	0
1250	9.687	0.281	0.711	0.079	0.506	1.968	4.994	0	1.968	17.251	0
1500	8.274	0.597	0.856	0.357	0.733	2.035	4.28	0	2.035	9.529	0
1750	12.553	0.053	0.541	0.003	0.293	1.969	0.861	0.195	1.969	10.472	0
2000	14.444	-0.101	-0.028	0.01	0.001	-1.969	-1.608	0.055	-1.969	-0.45	0.327
2250	12.67	-0.153	0.622	0.023	0.387	-1.969	-2.457	0.007	1.969	12.605	0
2500	11.465	0.097	0.776	0.009	0.602	1.971	1.472	0.071	1.971	18.476	0
2750	12.088	0.179	0.705	0.032	0.497	1.971	2.647	0.004	1.971	14.479	0
3000	12.331	0.189	0.686	0.036	0.47	1.972	2.696	0.004	1.972	13.222	0
3250	13.612	0.284	0.6	0.081	0.36	1.973	3.971	0	1.973	10.059	0
3500	13.902	0.351	0.592	0.123	0.35	1.973	4.985	0	1.973	9.761	0
3750	14.334	0.249	0.639	0.062	0.408	1.974	3.331	0.001	1.974	10.767	0
4000	13.528	0.358	0.607	0.128	0.368	1.977	4.53	0	1.977	9.028	0
4250	11.642	0.253	0.387	0.064	0.15	1.977	3.132	0.001	1.977	5.037	0
4500	14.197	0.003	0.293	0	0.086	1.988	0.031	0.488	1.988	2.821	0.003
4750	22.026	-0.429	0.302	0.184	0.091	-2.03	-2.808	0.004	2.03	1.875	0.035
5000	19.991	0.06	0.273	0.004	0.293	2.023	0.376	0.354	2.023	1.77	0.042
5250	20.986	0.334	-0.22	0.111	0.36	2.228	1.119	0.145	-2.228	-0.714	0.246
5500	28.531	-0.531	0.814	0.282	0.091	-2.201	-2.078	0.031	2.201	4.649	0
5750	27.055	-0.83	0.73	0.688	0.293	-2.11	-6.124	0	2.11	4.41	0
6000	29.867	-0.799	0.503	0.639	0.36	-2.086	-5.947	0	2.086	2.602	0.009

Avg. rmsvd = 15.332 Avg. (r^2) u = 0.150 Avg (r^2) v = 0.327

Vandenberg - Summer 1996: Profiler / VAD (modified) (Range 24.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	8.616	0.468	0.535	0.219	0.287	1.986	5.13	0	1.986	6.144	0
750	12.13	0.358	0.234	0.128	0.055	1.986	3.718	0	1.986	2.336	0.011
1000	8.716	0.445	0.7	0.198	0.49	1.967	9.152	0	1.967	18.049	0
1250	9.493	0.306	0.718	0.094	0.516	1.968	5.572	0	1.968	17.868	0
1500	8.274	0.597	0.856	0.357	0.733	2.035	4.28	0	2.035	9.529	0
1750	12.553	0.053	0.541	0.003	0.293	1.969	0.861	0.195	1.969	10.472	0
2000	12.978	-0.029	-0.202	0.001	0.041	-1.97	-0.436	0.332	-1.97	-3.117	0.001
2250	11.39	-0.028	0.714	0.001	0.51	-1.97	-0.419	0.338	1.97	15.435	0
2500	11.465	0.097	0.776	0.009	0.602	1.971	1.472	0.071	1.971	18.476	0
2750	12.088	0.179	0.705	0.032	0.497	1.971	2.647	0.004	1.971	14.479	0
3000	12.331	0.189	0.686	0.036	0.47	1.972	2.696	0.004	1.972	13.222	0
3250	13.612	0.284	0.6	0.081	0.36	1.973	3.971	0	1.973	10.059	0
3500	13.902	0.351	0.592	0.123	0.35	1.973	4.985	0	1.973	9.761	0
3750	14.321	0.249	0.635	0.062	0.404	1.974	3.344	0.001	1.974	10.699	0
4000	13.528	0.358	0.607	0.128	0.368	1.977	4.53	0	1.977	9.028	0
4250	11.642	0.253	0.387	0.064	0.15	1.977	3.132	0.001	1.977	5.037	0
4500	14.197	0.003	0.293	0	0.086	1.988	0.031	0.488	1.988	2.821	0.003
4750	22.026	-0.429	0.302	0.184	0.091	-2.03	-2.808	0.004	2.03	1.875	0.035
5000	19.991	0.06	0.273	0.004	0.293	2.023	0.376	0.354	2.023	1.77	0.042
5250	20.986	0.334	-0.22	0.111	0.36	2.228	1.119	0.145	-2.228	-0.714	0.246
5500	21.829	-0.521	0.744	0.272	0.091	-2.131	-2.365	0.016	2.131	4.309	0
5750	27.055	-0.83	0.73	0.688	0.293	-2.11	-6.124	0	2.11	4.41	0
6000	29.867	-0.799	0.503	0.639	0.36	-2.086	-5.947	0	2.086	2.602	0.009

Avg. rmsvd = 14.913 Avg. (r^2) u = 0.149 Avg (r^2) v = 0.335

Vandenberg - Summer 1996: Profiler / VAD (modified) (Range 22.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	8.616	0.468	0.535	0.219	0.287	1.986	5.13	0	1.986	6.144	0
750	12.13	0.358	0.234	0.128	0.055	1.986	3.718	0	1.986	2.336	0.011
1000	8.716	0.445	0.7	0.198	0.49	1.967	9.152	0	1.967	18.049	0
1250	9.79	0.384	0.867	0.148	0.751	1.998	3.329	0.001	1.998	13.896	0
1500	8.769	0.727	0.777	0.529	0.603	2.02	6.784	0	2.02	7.892	0
1750	12.553	0.053	0.541	0.003	0.293	1.969	0.861	0.195	1.969	10.472	0
2000	12.978	-0.029	-0.202	0.001	0.041	-1.97	-0.436	0.332	-1.97	-3.117	0.001
2250	11.39	-0.028	0.714	0.001	0.51	-1.97	-0.419	0.338	1.97	15.435	0
2500	11.575	0.13	0.744	0.017	0.554	1.97	1.995	0.024	1.97	16.941	0
2750	12.088	0.179	0.705	0.032	0.497	1.971	2.647	0.004	1.971	14.479	0
3000	12.331	0.189	0.686	0.036	0.47	1.972	2.696	0.004	1.972	13.222	0
3250	13.819	0.338	0.565	0.114	0.319	1.973	4.846	0	1.973	9.23	0
3500	14.202	0.384	0.535	0.147	0.286	1.973	5.559	0	1.973	8.462	0
3750	14.321	0.249	0.635	0.062	0.404	1.974	3.344	0.001	1.974	10.699	0
4000	13.528	0.358	0.607	0.128	0.368	1.977	4.53	0	1.977	9.028	0
4250	11.642	0.253	0.387	0.064	0.15	1.977	3.132	0.001	1.977	5.037	0
4500	14.197	0.003	0.293	0	0.086	1.988	0.031	0.488	1.988	2.821	0.003
4750	22.026	-0.429	0.302	0.184	0.091	-2.03	-2.808	0.004	2.03	1.875	0.035
5000	19.991	0.06	0.273	0.004	0.293	2.023	0.376	0.354	2.023	1.77	0.042
5250	21.163	-0.002	-0.011	0	0.319	-2.16	-0.008	0.497	-2.16	-0.04	0.484
5500	21.829	-0.521	0.744	0.272	0.091	-2.131	-2.365	0.016	2.131	4.309	0
5750	27.055	-0.83	0.73	0.688	0.293	-2.11	-6.124	0	2.11	4.41	0
6000	29.867	-0.799	0.503	0.639	0.319	-2.086	-5.947	0	2.086	2.602	0.009

Avg. rmsvd = 14.982 Avg. (r^2) u = 0.157 Avg (r^2) v = 0.329

Vandenberg - Summer 1996: Profiler / VAD (modified) (Range 20.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	8.616	0.468	0.535	0.219	0.287	1.986	5.13	0	1.986	6.144	0
750	12.13	0.358	0.234	0.128	0.055	1.986	3.718	0	1.986	2.336	0.011
1000	9.777	0.336	0.625	0.113	0.391	1.967	6.347	0	1.967	14.27	0
1250	10.356	0.364	0.743	0.133	0.552	1.994	3.295	0.001	1.994	9.35	0
1500	10.719	0.283	0.731	0.08	0.535	1.969	4.812	0	1.969	17.482	0
1750	10.778	0.035	0.769	0.001	0.592	1.97	0.55	0.291	1.97	18.645	0
2000	12.936	-0.048	-0.174	0.002	0.03	-1.97	-0.726	0.234	-1.97	-2.676	0.004
2250	11.421	-0.048	0.707	0.002	0.5	-1.97	-0.721	0.236	1.97	15.176	0
2500	11.533	0.116	0.726	0.013	0.527	1.97	1.78	0.038	1.97	16.084	0
2750	12.088	0.179	0.705	0.032	0.497	1.971	2.647	0.004	1.971	14.479	0
3000	12.267	0.219	0.672	0.048	0.451	1.972	3.173	0.001	1.972	12.818	0
3250	13.819	0.338	0.565	0.114	0.319	1.973	4.846	0	1.973	9.23	0
3500	14.202	0.384	0.535	0.147	0.286	1.973	5.559	0	1.973	8.462	0
3750	14.321	0.249	0.635	0.062	0.404	1.974	3.344	0.001	1.974	10.699	0
4000	13.528	0.358	0.607	0.128	0.368	1.977	4.53	0	1.977	9.028	0
4250	11.642	0.253	0.387	0.064	0.15	1.977	3.132	0.001	1.977	5.037	0
4500	14.206	-0.01	0.314	0	0.099	-1.988	-0.09	0.464	1.988	3.084	0.001
4750	20.84	-0.34	0.348	0.116	0.121	-2.032	-2.11	0.021	2.032	2.164	0.019
5000	18.813	0.207	0.31	0.043	0.592	2.024	1.302	0.1	2.024	2.008	0.026
5250	21.163	-0.002	-0.011	0	0.319	-2.16	-0.008	0.497	-2.16	-0.04	0.484
5500	21.829	-0.521	0.744	0.272	0.121	-2.131	-2.365	0.016	2.131	4.309	0
5750	27.055	-0.83	0.73	0.688	0.592	-2.11	-6.124	0	2.11	4.41	0
6000	29.867	-0.799	0.503	0.639	0.319	-2.086	-5.947	0	2.086	2.602	0.009

Avg. rmsvd = 14.953 Avg. (r^2) u = 0.132 Avg (r^2) v = 0.352

Vandenberg - Summer 1996: Profiler / VAD (modified) (Range 32.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
500	8.616	0.468	0.535	0.219	0.287	1.986	5.13	0	1.986	6.144	0
750	12.13	0.358	0.234	0.128	0.055	1.986	3.718	0	1.986	2.336	0.011
1000	15.369	0.121	0.374	0.015	0.14	2.008	0.87	0.194	2.008	2.884	0.003
1250	9.526	0.304	0.721	0.093	0.52	1.968	5.424	0	1.968	17.676	0
1500	8.232	0.663	0.861	0.44	0.741	2.03	5.241	0	2.03	10.001	0
1750	10.302	0.164	0.367	0.027	0.135	2.056	0.849	0.202	2.056	2.013	0.027
2000	14.444	-0.101	-0.028	0.01	0.001	-1.969	-1.608	0.055	-1.969	-0.45	0.327
2250	12.67	-0.153	0.622	0.023	0.387	-1.969	-2.457	0.007	1.969	12.605	0
2500	13.593	-0.27	0.56	0.073	0.313	-1.97	-4.224	0	1.97	10.18	0
2750	12.155	0.118	0.719	0.014	0.518	1.971	1.729	0.043	1.971	15.082	0
3000	12.406	0.202	0.675	0.041	0.456	1.972	2.905	0.002	1.972	12.875	0
3250	13.612	0.284	0.6	0.081	0.36	1.973	3.971	0	1.973	10.059	0
3500	13.902	0.351	0.592	0.123	0.35	1.973	4.985	0	1.973	9.761	0
3750	14.334	0.249	0.639	0.062	0.408	1.974	3.331	0.001	1.974	10.767	0
4000	13.447	0.361	0.598	0.131	0.357	1.977	4.617	0	1.977	8.881	0
4250	11.694	0.243	0.401	0.059	0.161	1.977	3.001	0.002	1.977	5.258	0
4500	14.172	0.001	0.298	0	0.089	1.988	0.007	0.497	1.988	2.916	0.002
4750	22.026	-0.429	0.302	0.184	0.091	-2.03	-2.808	0.004	2.03	1.875	0.035
5000	19.991	0.06	0.273	0.004	0.135	2.023	0.376	0.354	2.023	1.77	0.042
5250	20.986	0.334	-0.22	0.111	0.36	2.228	1.119	0.145	-2.228	-0.714	0.246
5500	28.531	-0.531	0.814	0.282	0.091	-2.201	-2.078	0.031	2.201	4.649	0
5750	35.252	-0.895	0.752	0.801	0.135	-2.16	-7.223	0	2.16	4.108	0.001
6000	30.808	-0.792	0.667	0.627	0.36	-2.093	-5.652	0	2.093	3.903	0

Avg. rmsvd = 16.008 Avg. (r^2) u = 0.154 Avg (r^2) v = 0.280

APPENDIX D

This appendix lists the statistical data calculated for the comparisons discussed in Chapter 6. This appendix lists the statistical data for the comparison between the rawinsonde data and the modified VAD wind data. There are a total of 24 tables of statistical data. Each season has six tables corresponding to the six changes made to the VAD range adaptable parameter. These values are 28.0, 26.0, 24.0, 22.0, 20.0, and 32.0 km. The corresponding values for the default value of 30.0 km can be found in section two of appendix B. An explanation of the tables in this appendix is listed below:

Hgt (m) - Height
Rmsvd (kts) - Root Mean Square Vector Difference (knots)
(r) u - Correlation (r), U -component
(r) v - Correlation (r), V -component
(r^2) u - Coefficient of determination (r^2), U - component
(r^2) v - Coefficient of determination (r^2), V - component
tcrit u - Critical value of t-test for U - component
tstar u - Calculated value of t test statistic for U- component
pval u - P-value calculated for U -component
tcrit v - Critical value of t-test for V - component
tstar v - Calculated value of t test statistic for V -component
pval v - P-value calculated for V -component

Note:

In the following tables, a height followed by all zeros in the same row indicates there were no matches found at that height, therefore, no statistics were calculated for that height. A height followed by an RMSVD value, then a dummy value of 2 for the (r) and (r^2) values, indicates there were only 1 or 2 matches between the u and v components at this height. The RMSVD value can be calculated; however, for only 1 match, the (r) value would be infinite, for 2 matches, the (r) value would be 1. Therefore, for these cases, the dummy value of 2 was assigned to the (r) and (r^2) values. However, these values of 2 were not plotted in the graphical plots in Chapters 4, 5, and 6.

Statistical data for the comparison between the rawinsonde data and the modified VAD wind data

Fall 1995

Vandenberg - Fall 1995: Rawinsonde/VAD (modified) (Range 28.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	0	0	0	0	0	0	0	0	0	0	0
900	10.17	-0.949	0.901	0.9	0.811	-12.706	-2.999	0.102	12.706	2.072	0.143
1200	9.194	-0.591	0.998	0.35	0.997	-12.706	-0.733	0.299	12.706	16.942	0.019
1500	0	0	0	0	0	0	0	0	0	0	0
1800	0	0	0	0	0	0	0	0	0	0	0
2100	19.067	2	2	2	2	0	0	0	0	0	0
2400	5.92	0.971	0.855	0.942	0.731	12.706	4.041	0.077	12.706	1.65	0.173
2700	4.488	2	2	2	2	0	0	0	0	0	0
3000	0	0	0	0	0	0	0	0	0	0	0
3300	6.26	2	2	2	2	0	0	0	0	0	0
3600	2.945	2	2	2	2	0	0	0	0	0	0
3900	9.543	2	2	2	2	0	0	0	0	0	0
4200	1.222	2	2	2	2	0	0	0	0	0	0
4500	0	0	0	0	0	0	0	0	0	0	0
4800	6.535	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0	0	0	0

Avg. rmsvd = 7.534 Avg. (r^2) u = 0.731 Avg (r^2) v = 0.846

Vandenberg - Fall 1995: Rawinsonde/VAD (modified) (Range 26.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	0	0	0	0	0	0	0	0	0	0	0
900	10.17	-0.949	0.901	0.9	0.811	-12.706	-2.999	0.102	12.706	2.072	0.143
1200	9.194	-0.591	0.998	0.35	0.997	-12.706	-0.733	0.299	12.706	16.942	0.019
1500	0	0	0	0	0	0	0	0	0	0	0
1800	16.135	2	2	2	2	0	0	0	0	0	0
2100	19.067	2	2	2	2	0	0	0	0	0	0
2400	5.92	0.971	0.855	0.942	0.731	12.706	4.041	0.077	12.706	1.65	0.173
2700	4.488	2	2	2	2	0	0	0	0	0	0
3000	0	0	0	0	0	0	0	0	0	0	0
3300	6.26	2	2	2	2	0	0	0	0	0	0
3600	2.945	2	2	2	2	0	0	0	0	0	0
3900	9.543	2	2	2	2	0	0	0	0	0	0
4200	1.222	2	2	2	2	0	0	0	0	0	0
4500	0	0	0	0	0	0	0	0	0	0	0
4800	6.535	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0	0	0	0

Avg. rmsvd = 8.316 Avg. (r^2) u = 0.731 Avg (r^2) v = 0.846

Vandenberg - Fall 1995: Rawinsonde/VAD (modified) (Range 24.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	0	0	0	0	0	0	0	0	0	0	0
900	10.17	-0.949	0.901	0.9	0.811	-12.706	-2.999	0.102	12.706	2.072	0.143
1200	9.194	-0.591	0.998	0.35	0.997	-12.706	-0.733	0.299	12.706	16.942	0.019
1500	0	0	0	0	0	0	0	0	0	0	0
1800	16.135	2	2	2	2	0	0	0	0	0	0
2100	10.815	2	2	2	2	0	0	0	0	0	0
2400	5.92	0.971	0.855	0.942	0.731	12.706	4.041	0.077	12.706	1.65	0.173
2700	4.488	2	2	2	2	0	0	0	0	0	0
3000	0	0	0	0	0	0	0	0	0	0	0
3300	6.26	2	2	2	2	0	0	0	0	0	0
3600	2.945	2	2	2	2	0	0	0	0	0	0
3900	9.543	2	2	2	2	0	0	0	0	0	0
4200	1.222	2	2	2	2	0	0	0	0	0	0
4500	0	0	0	0	0	0	0	0	0	0	0
4800	6.535	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0	0	0	0

Avg. rmsvd = 7.566　　Avg. (r^2) u = 0.731　　Avg (r^2) v = 0.846

Vandenberg - Fall 1995: Rawinsonde/VAD (modified) (Range 22.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	0	0	0	0	0	0	0	0	0	0	0
900	10.17	-0.949	0.901	0.9	0.811	-12.706	-2.999	0.102	12.706	2.072	0.143
1200	0	0	0	0	0	0	0	0	0	0	0
1500	0	0	0	0	0	0	0	0	0	0	0
1800	16.135	2	2	2	2	0	0	0	0	0	0
2100	10.815	2	2	2	2	0	0	0	0	0	0
2400	5.92	0.971	0.855	0.942	0.731	12.706	4.041	0.077	12.706	1.65	0.173
2700	4.488	2	2	2	2	0	0	0	0	0	0
3000	0	0	0	0	0	0	0	0	0	0	0
3300	6.26	2	2	2	2	0	0	0	0	0	0
3600	2.945	2	2	2	2	0	0	0	0	0	0
3900	9.543	2	2	2	2	0	0	0	0	0	0
4200	1.222	2	2	2	2	0	0	0	0	0	0
4500	0	0	0	0	0	0	0	0	0	0	0
4800	6.535	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0	0	0	0

Avg. rmsvd = 7.403 Avg. (r^2) u = 0.921 Avg (r^2) v = 0.771

Vandenberg - Fall 1995: Rawinsonde/VAD (modified) (Range 20.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	0	0	0	0	0	0	0	0	0	0	0
900	10.17	-0.949	0.901	0.9	0.811	-12.706	-2.999	0.102	12.706	2.072	0.143
1200	0	0	0	0	0	0	0	0	0	0	0
1500	12.287	2	2	2	2	0	0	0	0	0	0
1800	16.242	2	2	2	2	0	0	0	0	0	0
2100	10.815	2	2	2	2	0	0	0	0	0	0
2400	5.92	0.971	0.855	0.942	0.731	12.706	4.041	0.077	12.706	1.65	0.173
2700	4.488	2	2	2	2	0	0	0	0	0	0
3000	0	0	0	0	0	0	0	0	0	0	0
3300	6.26	2	2	2	2	0	0	0	0	0	0
3600	2.945	2	2	2	2	0	0	0	0	0	0
3900	9.543	2	2	2	2	0	0	0	0	0	0
4200	1.222	2	2	2	2	0	0	0	0	0	0
4500	0	0	0	0	0	0	0	0	0	0	0
4800	6.535	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0	0	0	0

Avg. rmsvd = 7.857   Avg. (r^2) u = 0.921   Avg (r^2) v = 0.771

Vandenberg - Fall 1995: Rawinsonde/VAD (modified) (Range 32.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	0	0	0	0	0	0	0	0	0	0	0
900	0	0	0	0	0	0	0	0	0	0	0
1200	9.194	-0.591	0.998	0.35	0.997	-12.706	-0.733	0.299	12.706	16.942	0.019
1500	0	0	0	0	0	0	0	0	0	0	0
1800	0	0	0	0	0	0	0	0	0	0	0
2100	19.067	2	2	2	2	0	0	0	0	0	0
2400	16.688	2	2	2	2	0	0	0	0	0	0
2700	4.488	2	2	2	2	0	0	0	0	0	0
3000	0	0	0	0	0	0	0	0	0	0	0
3300	6.26	2	2	2	2	0	0	0	0	0	0
3600	2.945	2	2	2	2	0	0	0	0	0	0
3900	9.543	2	2	2	2	0	0	0	0	0	0
4200	1.222	2	2	2	2	0	0	0	0	0	0
4500	0	0	0	0	0	0	0	0	0	0	0
4800	6.535	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0	0	0	0

Avg. rmsvd = 8.438 Avg. (r^2) u = 0.350 Avg (r^2) v = 0.997

Winter 1996

Vandenberg - Winter 1996: Rawinsonde/VAD (modified) (Range 28.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	20.378	0.78	0.403	0.609	0.163	2.306	3.531	0.004	2.306	1.246	0.124
900	5.469	0.957	0.985	0.917	0.97	2.447	8.128	0	2.447	13.911	0
1200	11.69	0.911	0.861	0.83	0.742	2.306	6.24	0	2.306	4.798	0.001
1500	7.529	0.997	0.969	0.993	0.938	4.303	80.252	0	2.306	5.517	0.016
1800	3.088	0.896	0.999	0.803	0.999	3.182	3.496	0.02	3.182	46.79	0
2100	7.706	0.852	0.974	0.726	0.949	2.776	3.258	0.016	2.776	8.601	0.001
2400	11.222	0.708	0.653	0.501	0.426	4.303	1.418	0.146	4.303	1.219	0.173
2700	10.441	0.722	0.977	0.521	0.954	2.776	2.086	0.053	2.776	9.153	0
3000	15.142	0.55	0.996	0.303	0.992	4.303	0.932	0.225	4.303	15.515	0.002
3300	2.766	2	2	2	2	0	0	0	0	0	0
3600	14.558	0.101	0.969	0.01	0.938	4.303	0.143	0.45	4.303	5.505	0.016
3900	0	0	0	0	0	0	0	0	0	0	0
4200	6.674	-0.101	-0.272	0.01	0.074	-2.776	-0.202	0.425	-2.776	-0.565	0.301
4500	0	0	0	0	0	0	0	0	0	0	0
4800	2.804	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	2.971	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 8.746 Avg. (r^2) u = 0.566 Avg (r^2) v = 0.740

Vandenberg - Winter 1996: Rawinsonde/VAD (modified) (Range 26.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	20.378	0.78	0.403	0.609	0.163	2.306	3.531	0.004	2.306	1.246	0.124
900	5.469	0.957	0.985	0.917	0.97	2.447	8.128	0	2.447	13.911	0
1200	11.69	0.911	0.861	0.83	0.742	2.306	6.24	0	2.306	4.798	0.001
1500	7.529	0.997	0.969	0.993	0.938	4.303	80.252	0	2.306	5.517	0.016
1800	3.088	0.896	0.999	0.803	0.999	3.182	3.496	0.02	3.182	46.79	0
2100	7.706	0.852	0.974	0.726	0.949	2.776	3.258	0.016	2.776	8.601	0.001
2400	11.222	0.708	0.653	0.501	0.426	4.303	1.418	0.146	4.303	1.219	0.173
2700	12.437	0.922	0.983	0.849	0.965	4.303	3.356	0.039	4.303	7.478	0.009
3000	15.142	0.55	0.996	0.303	0.992	4.303	0.932	0.225	4.303	15.515	0.002
3300	2.766	2	2	2	2	0	0	0	0	0	0
3600	14.558	0.101	0.969	0.01	0.938	4.303	0.143	0.45	4.303	5.505	0.016
3900	0	0	0	0	0	0	0	0	0	0	0
4200	6.674	-0.101	-0.272	0.01	0.074	-2.776	-0.202	0.425	-2.776	-0.565	0.301
4500	0	0	0	0	0	0	0	0	0	0	0
4800	2.804	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	7.611	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 9.220 Avg. (r^2) u = 0.596 Avg (r^2) v = 0.742

Vandenberg - Winter 1996: Rawinsonde/VAD (modified) (Range 24.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	20.378	0.78	0.403	0.609	0.163	2.306	3.531	0.004	2.306	1.246	0.124
900	5.469	0.957	0.985	0.917	0.97	2.447	8.128	0	2.447	13.911	0
1200	12.004	0.845	0.8	0.714	0.639	2.262	4.74	0.001	2.262	3.995	0.002
1500	7.529	0.997	0.969	0.993	0.938	4.303	80.252	0	2.262	5.517	0.016
1800	3.088	0.896	0.999	0.803	0.999	3.182	3.496	0.02	3.182	46.79	0
2100	12.005	0.857	0.833	0.735	0.694	4.303	2.352	0.071	4.303	2.132	0.083
2400	11.222	0.708	0.653	0.501	0.426	4.303	1.418	0.146	4.303	1.219	0.173
2700	12.437	0.922	0.983	0.849	0.965	4.303	3.356	0.039	4.303	7.478	0.009
3000	15.142	0.55	0.996	0.303	0.992	4.303	0.932	0.225	4.303	15.515	0.002
3300	2.766	2	2	2	2	0	0	0	0	0	0
3600	13.815	0.378	0.959	0.143	0.919	3.182	0.707	0.265	3.182	5.843	0.005
3900	0	0	0	0	0	0	0	0	0	0	0
4200	6.674	-0.101	-0.272	0.01	0.074	-2.776	-0.202	0.425	-2.776	-0.565	0.301
4500	0	0	0	0	0	0	0	0	0	0	0
4800	2.804	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	12.249	2	2	2	2	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	7.611	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 9.680 Avg. (r^2) u = 0.598 Avg (r^2) v = 0.707

Vandenberg - Winter 1996: Rawinsonde/VAD (modified) (Range 22.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	20.378	0.78	0.403	0.609	0.163	2.306	3.531	0.004	2.306	1.246	0.124
900	5.469	0.957	0.985	0.917	0.97	2.447	8.128	0	2.447	13.911	0
1200	8.091	0.967	0.993	0.936	0.986	2.571	8.53	0	2.571	18.991	0
1500	6.666	0.984	0.971	0.969	0.944	2.776	80.252	0	2.571	8.175	0.001
1800	3.088	0.896	0.999	0.803	0.999	3.182	3.496	0.02	3.182	46.79	0
2100	12.005	0.857	0.833	0.735	0.694	4.303	2.352	0.071	4.303	2.132	0.083
2400	11.555	0.921	0.667	0.849	0.445	4.303	3.348	0.039	4.303	1.266	0.167
2700	12.437	0.922	0.983	0.849	0.965	4.303	3.356	0.039	4.303	7.478	0.009
3000	15.142	0.55	0.996	0.303	0.992	4.303	0.932	0.225	4.303	15.515	0.002
3300	8.451	2	2	2	2	0	0	0	0	0	0
3600	13.815	0.378	0.959	0.143	0.919	3.182	0.707	0.265	3.182	5.843	0.005
3900	0	0	0	0	0	0	0	0	0	0	0
4200	6.674	-0.101	-0.272	0.01	0.074	-2.776	-0.202	0.425	-2.776	-0.565	0.301
4500	0	0	0	0	0	0	0	0	0	0	0
4800	2.804	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	12.249	2	2	2	2	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	7.611	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 9.762 Avg. (r^2) u = 0.648 Avg (r^2) v = 0.741

Vandenberg - Winter 1996: Rawinsonde/VAD (modified) (Range 20.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	20.378	0.78	0.403	0.609	0.163	2.306	3.531	0.004	2.306	1.246	0.124
900	5.469	0.957	0.985	0.917	0.97	2.447	8.128	0	2.447	13.911	0
1200	8.091	0.967	0.993	0.936	0.986	2.571	8.53	0	2.571	18.991	0
1500	6.286	0.954	0.978	0.91	0.956	2.571	80.252	0	2.571	10.39	0
1800	7.041	0.981	0.991	0.963	0.982	2.776	10.244	0	2.776	14.593	0
2100	12.005	0.857	0.833	0.735	0.694	4.303	2.352	0.071	4.303	2.132	0.083
2400	11.555	0.921	0.667	0.849	0.445	4.303	3.348	0.039	4.303	1.266	0.167
2700	12.437	0.922	0.983	0.849	0.965	4.303	3.356	0.039	4.303	7.478	0.009
3000	18.49	0.488	0.718	0.238	0.515	3.182	0.969	0.202	3.182	1.786	0.086
3300	8.451	2	2	2	2	0	0	0	0	0	0
3600	13.815	0.378	0.959	0.143	0.919	3.182	0.707	0.265	3.182	5.843	0.005
3900	0	0	0	0	0	0	0	0	0	0	0
4200	6.674	-0.101	-0.272	0.01	0.074	-2.776	-0.202	0.425	-2.776	-0.565	0.301
4500	0	0	0	0	0	0	0	0	0	0	0
4800	0	0	0	0	0	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	12.249	2	2	2	2	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	7.611	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 10.754 Avg. (r^2) u = 0.651 Avg (r^2) v = 0.697

Vandenberg - Winter 1996: Rawinsonde/VAD (modified) (Range 32.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit u	tstar u	pval v
600	20.378	0.78	0.403	0.609	0.163	2.306	3.531	0.004	2.306	1.246	0.124
900	12.986	0.978	0.884	0.957	0.782	2.571	10.514	0	2.571	4.229	0.004
1200	11.69	0.911	0.861	0.83	0.742	2.306	6.24	0	2.306	4.798	0.001
1500	7.529	0.997	0.969	0.993	0.938	4.303	80.252	0	2.306	5.517	0.016
1800	0.942	2	2	2	2	0	0	0	0	0	0
2100	7.706	0.852	0.974	0.726	0.949	2.776	3.258	0.016	2.776	8.601	0.001
2400	7.776	0.735	0.524	0.54	0.275	2.571	2.421	0.03	2.571	1.377	0.114
2700	10.441	0.722	0.977	0.521	0.954	2.776	2.086	0.053	2.776	9.153	0
3000	15.615	0.558	0.999	0.311	0.998	4.303	0.95	0.221	4.303	34.474	0
3300	2.766	2	2	2	2	0	0	0	0	0	0
3600	14.558	0.101	0.969	0.01	0.938	4.303	0.143	0.45	4.303	5.505	0.016
3900	0	0	0	0	0	0	0	0	0	0	0
4200	10.976	2	2	2	2	0	0	0	0	0	0
4500	0	0	0	0	0	0	0	0	0	0	0
4800	2.804	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	2.971	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 9.224 Avg. (r^2) u = 0.611 Avg (r^2) v = 0.749

Spring 1996

Vandenberg - Spring 1996: Rawinsonde/VAD (modified) (Range 28.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tcrit u	pval u	tcrit v	tstar v	pval v
600	5.563	2	2	2	2	0	0	0	0	0	0
900	20.169	0.396	-0.158	0.157	0.025	2.145	1.614	0.064	-2.145	-0.598	0.28
1200	21.336	-0.225	-0.046	0.05	0.002	-2.179	-0.798	0.22	-2.179	-0.161	0.437
1500	0	0	0	0	0	0	0	0	0	0	0
1800	0	0	0	0	0	0	0	0	0	0	0
2100	22.668	0.167	0.498	0.028	0.248	2.131	0.657	0.261	2.131	2.222	0.021
2400	20.305	-0.049	0.428	0.002	0.183	-2.201	-0.164	0.436	2.201	1.57	0.072
2700	19.232	-0.03	0.64	0.001	0.41	-2.262	-0.09	0.465	2.262	2.501	0.017
3000	5.193	2	2	2	2	0	0	0	0	0	0
3300	21.435	-0.257	0.85	0.066	0.722	-2.447	-0.652	0.265	2.447	2.153	0.03
3600	31.145	-0.754	0.937	0.569	0.877	-2.776	-2.297	0.042	2.776	5.342	0.003
3900	0	0	0	0	0	0	0	0	0	0	0
4200	29.216	0.76	0.136	0.578	0.019	2.776	2.339	0.04	2.776	0.275	0.399
4500	0	0	0	0	0	0	0	0	0	0	0
4800	29.285	0.611	0.376	0.373	0.142	2.776	1.542	0.099	2.776	0.812	0.231
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	33.252	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 21.567 Avg. (r^2) u = 0.203 Avg (r^2) v = 0.292

Vandenberg - Spring 1996: Rawinsonde/VAD (modified) (Range 26.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	5.563	2	2	2	2	0	0	0	0	0	0
900	20.169	0.396	-0.158	0.157	0.025	2.145	1.614	0.064	-2.145	-0.598	0.28
1200	21.336	-0.225	-0.046	0.05	0.002	-2.179	-0.798	0.22	-2.179	-0.161	0.437
1500	0	0	0	0	0	0	0	0	0	0	0
1800	19.001	0.333	0.491	0.111	0.241	2.131	1.369	0.096	2.131	2.183	0.023
2100	22.668	0.167	0.498	0.028	0.248	2.131	0.657	0.261	2.131	2.222	0.021
2400	20.305	-0.049	0.428	0.002	0.183	-2.201	-0.164	0.436	2.201	1.57	0.072
2700	19.232	-0.03	0.64	0.001	0.41	-2.262	-0.09	0.465	2.262	2.501	0.017
3000	5.193	2	2	2	2	0	0	0	0	0	0
3300	21.435	-0.257	0.85	0.066	0.722	-2.447	-0.652	0.265	2.447	2.153	0.03
3600	31.145	-0.754	0.937	0.569	0.877	-2.776	-2.297	0.042	2.776	5.342	0.003
3900	0	0	0	0	0	0	0	0	0	0	0
4200	29.216	0.76	0.136	0.578	0.019	2.776	2.339	0.04	2.776	0.275	0.399
4500	0	0	0	0	0	0	0	0	0	0	0
4800	29.285	0.611	0.376	0.373	0.142	2.776	1.542	0.099	2.776	0.812	0.231
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	33.252	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 21.369 Avg. (r^2) u = 0.194 Avg (r^2) v = 0.287

Vandenberg - Spring 1996: Rawinsonde/VAD (modified) (Range 24.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	5.563	2	2	2	2	0	0	0	0	0	0
900	20.169	0.396	-0.158	0.157	0.025	2.145	1.614	0.064	-2.145	-0.598	0.28
1200	21.336	-0.225	-0.046	0.05	0.002	-2.179	-0.798	0.22	-2.179	-0.161	0.437
1500	0	0	0	0	0	0	0	0	0	0	0
1800	19.001	0.333	0.491	0.111	0.241	2.131	1.369	0.096	2.131	2.183	0.023
2100	19.069	0.134	0.403	0.018	0.162	2.201	0.449	0.331	2.201	1.46	0.086
2400	20.305	-0.049	0.428	0.002	0.183	-2.201	-0.164	0.436	2.201	1.57	0.072
2700	19.232	-0.03	0.64	0.001	0.41	-2.262	-0.09	0.465	2.262	2.501	0.017
3000	5.193	2	2	2	2	0	0	0	0	0	0
3300	21.435	-0.257	0.85	0.066	0.722	-2.447	-0.652	0.265	2.447	2.153	0.03
3600	31.145	-0.754	0.937	0.569	0.877	-2.776	-2.297	0.042	2.776	5.342	0.003
3900	0	0	0	0	0	0	0	0	0	0	0
4200	29.216	0.76	0.136	0.578	0.019	2.776	2.339	0.04	2.776	0.275	0.399
4500	0	0	0	0	0	0	0	0	0	0	0
4800	29.285	0.611	0.376	0.373	0.142	2.776	1.542	0.099	2.776	0.812	0.231
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	33.252	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 21.092 Avg. (r^2) u = 0.193 Avg (r^2) v = 0.278

Vandenberg - Spring 1996: Rawinsonde/VAD (modified) (Range 22.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	5.563	2	2	2	2	0	0	0	0	0	0
900	20.169	0.396	-0.158	0.157	0.025	2.145	1.614	0.064	-2.145	-0.598	0.28
1200	0	0	0	0	0	0	0	0	0	0	0
1500	0	0	0	0	0	0	0	0	0	0	0
1800	19.001	0.333	0.491	0.111	0.241	2.131	1.369	0.096	2.131	2.183	0.023
2100	19.069	0.134	0.403	0.018	0.162	2.201	0.449	0.331	2.201	1.46	0.086
2400	20.305	-0.049	0.428	0.002	0.183	-2.201	-0.164	0.436	2.201	1.57	0.072
2700	19.232	-0.03	0.64	0.001	0.41	-2.262	-0.09	0.465	2.262	2.501	0.017
3000	5.193	2	2	2	2	0	0	0	0	0	0
3300	21.435	-0.257	0.85	0.066	0.722	-2.447	-0.652	0.265	2.447	2.153	0.03
3600	31.145	-0.754	0.937	0.569	0.877	-2.776	-2.297	0.042	2.776	5.342	0.003
3900	0	0	0	0	0	0	0	0	0	0	0
4200	29.216	0.76	0.136	0.578	0.019	2.776	2.339	0.04	2.776	0.275	0.399
4500	0	0	0	0	0	0	0	0	0	0	0
4800	29.285	0.611	0.376	0.373	0.142	2.776	1.542	0.099	2.776	0.812	0.231
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	33.252	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 21.072 Avg. (r^2) u = 0.208 Avg (r^2) v = 0.309

Vandenberg - Spring 1996: Rawinsonde/VAD (modified) (Range 20.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	5.563	2	2	2	2	0	0	0	0	0	0
900	20.169	0.396	-0.158	0.157	0.025	2.145	1.614	0.064	-2.145	-0.598	0.28
1200	0	0	0	0	0	0	0	0	0	0	0
1500	17.735	0.227	0.408	0.051	0.166	2.131	0.902	0.191	2.131	1.73	0.052
1800	16.602	0.144	0.408	0.021	0.166	2.179	0.503	0.312	2.179	1.548	0.074
2100	19.069	0.134	0.403	0.018	0.162	2.201	0.449	0.331	2.201	1.46	0.086
2400	20.305	-0.049	0.428	0.002	0.183	-2.201	-0.164	0.436	2.201	1.57	0.072
2700	19.232	-0.03	0.64	0.001	0.41	-2.262	-0.09	0.465	2.262	2.501	0.017
3000	5.193	2	2	2	2	0	0	0	0	0	0
3300	21.435	-0.257	0.85	0.066	0.722	-2.447	-0.652	0.265	2.447	2.153	0.03
3600	31.145	-0.754	0.937	0.569	0.877	-2.776	-2.297	0.042	2.776	5.342	0.003
3900	0	0	0	0	0	0	0	0	0	0	0
4200	29.216	0.76	0.136	0.578	0.019	2.776	2.339	0.04	2.776	0.275	0.399
4500	0	0	0	0	0	0	0	0	0	0	0
4800	29.285	0.611	0.376	0.373	0.142	2.776	1.542	0.099	2.776	0.812	0.231
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	33.252	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 20.631 Avg. (r^2) u = 0.184 Avg (r^2) v = 0.287

Vandenberg - Spring 1996: Rawinsonde/VAD (modified) (Range 32.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	5.563	2	2	2	2	0	0	0	0	0	0
900	17.445	2	2	2	2	0	0	0	0	0	0
1200	21.336	-0.225	-0.046	0.05	0.002	-2.179	-0.798	0.22	-2.179	-0.161	0.437
1500	0	0	0	0	0	0	0	0	0	0	0
1800	0	0	0	0	0	0	0	0	0	0	0
2100	22.668	0.167	0.498	0.028	0.248	2.131	0.657	0.261	2.131	2.222	0.021
2400	22.655	0.066	-0.058	0.004	0.003	2.12	0.263	0.398	-2.12	-0.233	0.409
2700	19.232	-0.03	0.64	0.001	0.41	-2.262	-0.09	0.465	2.262	2.501	0.017
3000	5.193	2	2	2	2	0	0	0	0	0	0
3300	21.435	-0.257	0.85	0.066	0.722	-2.447	-0.652	0.265	2.447	2.153	0.03
3600	31.145	-0.754	0.937	0.569	0.877	-2.776	-2.297	0.042	2.776	5.342	0.003
3900	0	0	0	0	0	0	0	0	0	0	0
4200	29.216	0.76	0.136	0.578	0.019	2.776	2.339	0.04	2.776	0.275	0.399
4500	0	0	0	0	0	0	0	0	0	0	0
4800	29.285	0.611	0.376	0.373	0.142	2.776	1.542	0.099	2.776	0.812	0.231
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	33.252	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 21.535 Avg. (r^2) u = 0.209 Avg (r^2) v = 0.303

Summer 1996

Vandenberg - Summer 1996: Rawinsonde/VAD (modified) (Range 28.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	10.553	0.419	0.118	0.176	0.014	2.776	0.923	0.204	2.776	0.238	0.412
900	8.78	0.583	0.779	0.34	0.606	2.086	3.208	0.002	2.086	5.548	0
1200	11.448	0.41	0.895	0.168	0.801	2.131	1.74	0.051	2.131	7.769	0
1500	2.373	2	2	2	2	0	0	0	0	0	0
1800	0	0	0	0	0	0	0	0	0	0	0
2100	12.628	0.443	0.89	0.196	0.792	2.16	1.781	0.049	2.16	7.03	0
2400	12.067	-0.383	0.288	0.147	0.083	-2.201	-1.375	0.098	2.201	0.999	0.17
2700	10.727	-0.508	0.868	0.258	0.754	-2.228	-1.863	0.046	2.228	5.54	0
3000	10.543	0.978	1	0.957	1	12.706	4.734	0.066	12.706	80.252	0.004
3300	12.33	0.168	0.689	0.028	0.474	2.179	0.59	0.284	2.179	2.42	0.018
3600	15.939	-0.361	0.358	0.13	0.128	-2.306	-1.093	0.153	2.306	1.086	0.155
3900	0	0	0	0	0	0	0	0	0	0	0
4200	12.924	-0.372	0.191	0.138	0.037	-2.365	-1.059	0.162	2.365	0.516	0.311
4500	0	0	0	0	0	0	0	0	0	0	0
4800	22.441	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	5.263	1	0.999	1	0.999	12.706	80.252	0.004	12.706	25.981	0.012

Avg. rmsvd = 11.386 Avg. (r^2) u = 0.322 Avg (r^2) v = 0.517

Vandenberg - Summer 1996: Rawinsonde/VAD (modified) (Range 26.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	10.553	0.419	0.118	0.176	0.014	2.776	0.923	0.204	2.776	0.238	0.412
900	8.78	0.583	0.779	0.34	0.606	2.086	3.208	0.002	2.086	5.548	0
1200	11.448	0.41	0.895	0.168	0.801	2.131	1.74	0.051	2.131	7.769	0
1500	2.373	2	2	2	2	0	0	0	0	0	0
1800	14.147	0.391	0.82	0.153	0.672	2.16	1.534	0.075	2.16	5.165	0
2100	12.628	0.443	0.89	0.196	0.792	2.16	1.781	0.049	2.16	7.03	0
2400	12.067	-0.383	0.288	0.147	0.083	-2.201	-1.375	0.098	2.201	0.999	0.17
2700	10.367	-0.354	0.864	0.125	0.747	-2.201	-1.254	0.118	2.201	5.695	0
3000	10.543	0.978	1	0.957	1	12.706	4.734	0.066	12.706	80.252	0.004
3300	12.33	0.168	0.689	0.028	0.474	2.179	0.59	0.284	2.179	2.42	0.017
3600	15.939	-0.361	0.358	0.13	0.128	-2.306	-1.093	0.153	2.306	1.086	0.155
3900	0	0	0	0	0	0	0	0	0	0	0
4200	12.924	-0.372	0.191	0.138	0.037	-2.365	-1.059	0.162	2.365	0.516	0.311
4500	0	0	0	0	0	0	0	0	0	0	0
4800	22.441	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	1.75	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 11.306 Avg. (r^2) u = 0.233 Avg (r^2) v = 0.487

Vandenberg - Summer 1996: Rawinsonde/VAD (modified) (Range 24.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	10.553	0.419	0.118	0.176	0.014	2.776	0.923	0.204	2.776	0.238	0.412
900	8.78	0.583	0.779	0.34	0.606	2.086	3.208	0.002	2.086	5.548	0
1200	12.066	0.137	0.885	0.019	0.784	2.145	0.518	0.306	2.145	7.121	0
1500	2.373	2	2	2	2	0	0	0	0	0	0
1800	14.147	0.391	0.82	0.153	0.672	2.16	1.534	0.075	2.16	5.165	0
2100	11.65	0.175	0.859	0.031	0.738	2.16	0.641	0.266	2.16	6.057	0
2400	12.067	-0.383	0.288	0.147	0.083	-2.201	-1.375	0.098	2.201	0.999	0.17
2700	10.367	-0.354	0.864	0.125	0.747	-2.201	-1.254	0.118	2.201	5.695	0
3000	10.543	0.978	1	0.957	1	12.706	4.734	0.066	12.706	80.252	0.004
3300	12.33	0.168	0.689	0.028	0.474	2.179	0.59	0.284	2.179	2.42	0.017
3600	15.939	-0.361	0.358	0.13	0.128	-2.306	-1.093	0.153	2.306	1.086	0.155
3900	0	0	0	0	0	0	0	0	0	0	0
4200	12.924	-0.372	0.191	0.138	0.037	-2.365	-1.059	0.162	2.365	0.516	0.311
4500	0	0	0	0	0	0	0	0	0	0	0
4800	22.441	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	1.75	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 11.281 Avg. (r^2) u = 0.204 Avg (r^2) v = 0.480

Vandenberg - Summer 1996: Rawinsonde/VAD (modified) (Range 22.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	10.553	0.419	0.118	0.176	0.014	2.776	0.923	0.204	2.776	0.238	0.412
900	8.78	0.583	0.779	0.34	0.606	2.086	3.208	0.002	2.086	5.548	0
1200	19.285	2	2	2	2	0	0	0	0	0	0
1500	10.95	2	2	2	2	0	0	0	0	0	0
1800	14.147	0.391	0.82	0.153	0.672	2.16	1.534	0.075	2.16	5.165	0
2100	11.65	0.175	0.859	0.031	0.738	2.16	0.641	0.266	2.16	6.057	0
2400	12.067	-0.383	0.288	0.147	0.083	-2.201	-1.375	0.098	2.201	0.999	0.17
2700	10.367	-0.354	0.864	0.125	0.747	-2.201	-1.254	0.118	2.201	5.695	0
3000	10.543	0.978	1	0.957	1	12.706	4.734	0.066	12.706	80.252	0.004
3300	11.949	0.175	0.7	0.031	0.491	2.179	0.616	0.275	2.179	2.464	0.016
3600	15.939	-0.361	0.358	0.13	0.128	-2.306	-1.093	0.153	2.306	1.086	0.155
3900	0	0	0	0	0	0	0	0	0	0	0
4200	12.924	-0.372	0.191	0.138	0.037	-2.365	-1.059	0.162	2.365	0.516	0.311
4500	0	0	0	0	0	0	0	0	0	0	0
4800	22.441	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	1.75	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 12.381 Avg. (r^2) u = 0.223 Avg (r^2) v = 0.452

Vandenberg - Summer 1996: Rawinsonde/VAD (modified) (Range 20.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	10.553	0.419	0.118	0.176	0.014	2.776	0.923	0.204	2.776	0.238	0.412
900	9.477	0.603	0.576	0.363	0.331	2.101	3.205	0.002	2.101	2.987	0.004
1200	13.405	1	1	0.999	1	12.706	34.064	0.009	12.706	80.252	0.004
1500	14.238	0.448	0.711	0.201	0.505	2.16	1.806	0.047	2.16	3.645	0.001
1800	16.184	0.418	0.863	0.174	0.744	2.306	1.3	0.115	2.306	4.826	0.001
2100	12.181	0.234	0.891	0.055	0.794	2.16	0.866	0.201	2.16	7.079	0
2400	12.138	-0.258	-0.098	0.066	0.01	-2.201	-0.885	0.198	-2.201	-0.325	0.376
2700	10.367	-0.354	0.864	0.125	0.747	-2.201	-1.254	0.118	2.201	5.695	0
3000	10.543	0.978	1	0.957	1	12.706	4.734	0.066	12.706	80.252	0.004
3300	11.949	0.175	0.7	0.031	0.491	2.179	0.616	0.275	2.179	2.464	0.016
3600	15.939	-0.361	0.358	0.13	0.128	-2.306	-1.093	0.153	2.306	1.086	0.155
3900	0	0	0	0	0	0	0	0	0	0	0
4200	12.924	-0.372	0.191	0.138	0.037	-2.365	-1.059	0.162	2.365	0.516	0.311
4500	0	0	0	0	0	0	0	0	0	0	0
4800	30.084	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	1.75	2	2	2	2	0	0	0	0	0	0

Avg. rmsvd = 12.981 Avg. (r^2) u = 0.285 Avg (r^2) v = 0.483

Vandenberg - Summer 1996: Rawinsonde/VAD (modified) (Range 32.0 km)

Hgt (m)	rmsvd (kts)	(r) u	(r) v	(r^2) u	(r^2) v	tcrit u	tstar u	pval u	tcrit v	tstar v	pval v
600	10.553	0.419	0.118	0.176	0.014	2.776	0.923	0.204	2.776	0.238	0.412
900	9.989	0.945	-0.665	0.894	0.442	12.706	2.903	0.106	-12.706	-0.89	0.268
1200	11.448	0.41	0.895	0.168	0.801	2.131	1.74	0.051	2.131	7.769	0
1500	2.373	2	2	2	2	0	0	0	0	0	0
1800	0	0	0	0	0	0	0	0	0	0	0
2100	12.628	0.443	0.89	0.196	0.792	2.16	1.781	0.049	2.16	7.03	0
2400	10.974	0.178	-0.242	0.032	0.059	2.201	0.601	0.28	-2.201	-0.828	0.213
2700	10.727	-0.508	0.868	0.258	0.754	-2.228	-1.863	0.046	2.228	5.54	0
3000	10.543	0.978	1	0.957	1	12.706	4.734	0.066	12.706	80.252	0.004
3300	12.33	0.168	0.689	0.028	0.474	2.179	0.59	0.284	2.179	2.42	0.018
3600	15.939	-0.361	0.358	0.13	0.128	-2.306	-1.093	0.153	2.306	1.086	0.155
3900	0	0	0	0	0	0	0	0	0	0	0
4200	13.658	-0.411	0.128	0.169	0.016	-2.447	-1.104	0.156	2.447	0.317	0.381
4500	0	0	0	0	0	0	0	0	0	0	0
4800	22.441	2	2	2	2	0	0	0	0	0	0
5100	0	0	0	0	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0	0	0	0	0
6000	5.263	1	0.999	1	0.999	12.706	80.252	0.004	12.706	25.981	0.012

Avg. rmsvd = 11.451 Avg. (r^2) u = 0.364 Avg (r^2) v = 0.498

APPENDIX E

Coefficient of determination (r^2) values from modification of the VAD range adaptable parameter for the comparison between the wind profiler and the VAD wind data

This appendix is a combination of section one of appendix B with appendix C. For a quick and easy comparison, the calculated coefficient of determination (r^2) values are listed for each value of the VAD range adaptable parameter used in the comparison between the wind profiler data and the VAD wind data. There are a total of eight tables. Each season has a table for the (r^2) values of the u-component and the v-component An explanation of the table is given below.

Note: A dummy value of 2 was assigned to heights where the (r^2) value was not calculated due to only one or two matches. An entire row of zeros was used if there was no match at a particular height. A single column may have a value of zero if the (r^2) value was smaller than three decimal places.

Fall 1995: Coefficient of determination (r^2) values for profiler/VAD comparison

U-component

Range value (km)	20.0	22.0	24.0	26.0	28.0	30.0 (Default)	32.0
Height (m)							
500	0.605	0.605	0.605	0.605	0.605	0.8	0.605
750	0.583	0.583	0.583	0.583	0.583	0.788	0.583
1000	0.137	0.137	0.137	0.137	0.137	0.182	0.983
1250	0	0	0.105	0.096	0.096	0.2	0.096
1500	0	0	2	2	2	2	2
1750	0.119	0.048	0.048	0.048	0	0.645	0
2000	0.137	0.137	0.137	0.013	0.013	0.188	0.013
2250	0.18	0.18	0.18	0.097	0.097	0.261	0.097
2500	0.428	0.428	0.428	0.428	0.428	0.062	0.115
2750	0.13	0.13	0.13	0.13	0.13	0.132	0.13
3000	0.051	0.051	0.051	0.051	0.051	0.067	0.051
3250	0.266	0.266	0.266	0.266	0.266	0.264	0.266
3500	0.282	0.282	0.282	0.282	0.282	0.294	0.282
3750	0.049	0.049	0.049	0.049	0.049	0.022	0.049
4000	0.064	0.064	0.064	0.064	0.064	0.056	0.064
4250	0.021	0.021	0.021	0.021	0.021	0	0.021
4500	2	2	2	2	2	0.394	2
4750	0	0	0	0	0	0	0
5000	0	0	0	0	0	0	0
5250	0	0	0	0	0	0	0
5500	0	0	0	0	0	0	0
5750	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0

Fall 1995: Coefficient of determination (r^2) values for profiler/VAD comparison

V - component

Range value (km)	20.0	22.0	24.0	26.0	28.0	30.0 (Default)	32.0
Height (m)							
500	0.172	0.172	0.172	0.172	0.172	0.934	0.172
750	0.581	0.581	0.581	0.581	0.581	0.037	0.581
1000	0.592	0.592	0.592	0.592	0.592	0.534	0.526
1250	0	0	0.292	0.253	0.253	0.291	0.253
1500	0.103	0	2	2	2	2	2
1750	0.236	0.032	0.032	0.032	0	0.25	0.324
2000	0.161	0.161	0.161	0.011	0.011	0.084	0.011
2250	0.018	0.018	0.018	0.424	0.424	0.12	0.424
2500	0.09	0.09	0.09	0.09	0.09	0.062	0.14
2750	0.102	0.102	0.102	0.102	0.102	0.15	0.102
3000	0.067	0.067	0.067	0.067	0.067	0.089	0.067
3250	0.086	0.086	0.086	0.086	0.086	0.094	0.086
3500	0.031	0.031	0.031	0.031	0.031	0.052	0.031
3750	0.037	0.037	0.037	0.037	0.037	0.001	0.037
4000	0.009	0.009	0.009	0.009	0.009	0.064	0.009
4250	0.001	0.001	0.001	0.001	0.001	0.233	0.001
4500	2	2	2	2	2	0.69	2
4750	0	0	0	0	0	0	0
5000	0	0	0	0	0	0	0
5250	0	0	0	0	0	0	0
5500	0	0	0	0	0	0	0
5750	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0

Winter 1996: Coefficient of determination (r^2) values for profiler/VAD comparison

U-component

Range value (km)	20.0	22.0	24.0	26.0	28.0	30.0 (Default)	32.0
Height (m)							
500	0.003	0.003	0.003	0.003	0.003	0.001	0.003
750	0.325	0.325	0.325	0.325	0.325	0.242	0.325
1000	0.358	0.358	0.358	0.358	0.358	0.375	0.52
1250	0.673	0.673	0.489	0.376	0.376	0.372	0.376
1500	0.637	0.702	0.624	0.624	0.624	0.639	0.624
1750	0.782	0.76	0.76	0.76	0.768	0.684	0.632
2000	0.756	0.756	0.756	0.627	0.627	0.646	0.627
2250	0.713	0.713	0.713	0.591	0.591	0.609	0.591
2500	0.65	0.65	0.708	0.708	0.708	0.588	0.544
2750	0.498	0.498	0.498	0.498	0.52	0.547	0.52
3000	0.496	0.483	0.483	0.483	0.483	0.448	0.453
3250	0.548	0.548	0.557	0.557	0.557	0.455	0.557
3500	0.523	0.523	0.466	0.466	0.466	0.371	0.466
3750	0.44	0.44	0.44	0.293	0.293	0.136	0.293
4000	0.7	0.7	0.7	0.7	0.596	0.603	0.596
4250	0.533	0.533	0.533	0.533	0.533	0.362	0.363
4500	0.616	0.609	0.609	0.609	0.609	0.563	0.359
4750	0.54	0.612	0.612	0.612	0.612	0.567	0.612
5000	0.486	0.56	0.56	0.56	0.56	0.511	0.56
5250	0.481	0.481	0.453	0.453	0.453	0.423	0.453
5500	0.715	0.715	0.715	0.58	0.58	0.562	0.58
5750	0.765	0.765	0.765	0.765	0.748	0.738	0.748
6000	0.772	0.772	0.772	0.772	0.787	0.719	0.787

Winter 1996: Coefficient of determination (r^2) values for profiler/VAD comparison

V -component

Range value (km)	20.0	22.0	24.0	26.0	28.0	30.0 (Default)	32.0
Height (m)							
500	0.35	0.35	0.35	0.35	0.35	0.344	0.35
750	0.388	0.388	0.388	0.388	0.388	0.418	0.388
1000	0.505	0.505	0.505	0.505	0.505	0.494	0.452
1250	0.45	0.45	0.353	0.548	0.548	0.554	0.548
1500	0.562	0.623	0.81	0.81	0.81	0.701	0.81
1750	0.317	0.611	0.611	0.611	0.833	0.827	0.827
2000	0.053	0.053	0.053	0.029	0.029	0.019	0.029
2250	0.12	0.12	0.12	0.324	0.324	0.448	0.324
2500	0.226	0.226	0.174	0.174	0.174	0.57	0.337
2750	0.533	0.533	0.533	0.533	0.444	0.516	0.444
3000	0.522	0.547	0.547	0.547	0.547	0.347	0.318
3250	0.495	0.495	0.213	0.213	0.213	0.241	0.213
3500	0.494	0.494	0.2	0.2	0.2	0.227	0.2
3750	0.786	0.786	0.786	0.752	0.752	0.463	0.752
4000	0.805	0.805	0.805	0.805	0.788	0.79	0.788
4250	0.798	0.798	0.798	0.798	0.798	0.728	0.712
4500	0.795	0.867	0.867	0.867	0.867	0.844	0.4
4750	0.787	0.354	0.354	0.354	0.354	0.322	0.354
5000	0.317	0.611	0.611	0.611	0.833	0.827	0.827
5250	0.495	0.495	0.213	0.213	0.213	0.241	0.213
5500	0.787	0.354	0.354	0.354	0.354	0.322	0.354
5750	0.317	0.611	0.611	0.611	0.833	0.827	0.827
6000	0.495	0.495	0.213	0.213	0.213	0.241	0.213

Spring 1996: Coefficient of determination (r^2) values for profiler/VAD comparison

U-component

Range value (km)	20.0	22.0	24.0	26.0	28.0	30.0 (Default)	32.0
Height (m)							
500	.36	0.36	0.36	0.36	0.36	0.36	0.36
750	0.284	0.284	0.284	0.284	0.284	0.284	0.284
1000	0.129	0.129	0.129	0.129	0.129	0.129	0.021
1250	0.503	0.503	0.154	0.127	0.127	0.127	0.127
1500	0.25	0.897	0.812	0.812	0.812	0.812	0.812
1750	0.384	0.296	0.296	0.296	0.792	0.844	0.844
2000	0.292	0.292	0.292	0.268	0.268	0.268	0.268
2250	0.221	0.221	0.221	0.253	0.253	0.253	0.253
2500	0.242	0.242	0.24	0.24	0.24	0.251	0.251
2750	0.232	0.232	0.232	0.232	0.227	0.227	0.227
3000	0.27	0.261	0.261	0.261	0.261	0.257	0.257
3250	0.245	0.245	0.239	0.239	0.239	0.239	0.239
3500	0.238	0.238	0.232	0.232	0.232	0.232	0.232
3750	0.216	0.216	0.216	0.231	0.231	0.231	0.231
4000	0.19	0.19	0.19	0.19	0.201	0.201	0.201
4250	0.296	0.296	0.296	0.296	0.296	0.324	0.324
4500	0.447	0.485	0.485	0.485	0.485	0.485	0.485
4750	0.435	0.435	0.435	0.435	0.435	0.435	0.435
5000	0.442	0.442	0.442	0.442	0.442	0.442	0.442
5250	0.604	0.604	0.604	0.604	0.604	0.604	0.604
5500	0.351	0.351	0.351	0.351	0.351	0.351	0.351
5750	0.477	0.477	0.477	0.477	0.477	0.477	0.477
6000	0.764	0.764	0.764	0.764	0.694	0.694	0.694

Spring 1996: Coefficient of determination (r^2) values for profiler/VAD comparison

V -component

Range value (km)	20.0	22.0	24.0	26.0	28.0	30.0	32.0
Height (m)							
500	0.19	0.19	0.19	0.19	0.19	0.19	0.19
750	0.036	0.036	0.036	0.036	0.036	0.036	0.036
1000	0.002	0.002	0.002	0.002	0.002	0.002	0.05
1250	0.017	0.017	0	0.002	0.002	0.002	0.002
1500	0.026	0.072	0.113	0.113	0.113	0.113	0.113
1750	0.064	0.088	0.088	0.088	0.31	0.106	0.106
2000	0.003	0.003	0.003	0.001	0.001	0.001	0.001
2250	0.146	0.146	0.146	0.159	0.159	0.159	0.159
2500	0.029	0.029	0.041	0.041	0.041	0.037	0.037
2750	0.012	0.012	0.012	0.012	0.012	0.012	0.012
3000	0.012	0.013	0.013	0.013	0.013	0.013	0.013
3250	0.016	0.016	0.015	0.015	0.015	0.015	0.015
3500	0.046	0.046	0.046	0.046	0.046	0.046	0.046
3750	0.008	0.008	0.008	0.008	0.008	0.008	0.008
4000	0.003	0.003	0.003	0.003	0.003	0.003	0.003
4250	0.003	0.003	0.003	0.003	0.003	0.003	0.003
4500	0.018	0.018	0.018	0.018	0.018	0.018	0.018
4750	0.024	0.024	0.024	0.024	0.024	0.024	0.024
5000	0.064	0.088	0.088	0.088	0.31	0.106	0.106
5250	0.016	0.016	0.015	0.015	0.015	0.015	0.015
5500	0.024	0.024	0.024	0.024	0.024	0.024	0.024
5750	0.064	0.088	0.088	0.088	0.31	0.106	0.106
6000	0.016	0.016	0.015	0.015	0.015	0.015	0.015

Summer 1996: Coefficient of determination (r^2) values for profiler/VAD comparison

U-component

Range value (km)	20.0	22.0	24.0	26.0	28.0	30.0 (Default)	32.0
Height (m)							
500	0.219	0.219	0.219	0.219	0.219	0.199	0.219
750	0.128	0.128	0.128	0.128	0.128	0.099	0.128
1000	0.113	0.198	0.198	0.198	0.198	0.198	0.015
1250	0.133	0.148	0.094	0.079	0.079	0.076	0.093
1500	0.08	0.529	0.357	0.357	0.357	0.357	0.44
1750	0.001	0.003	0.003	0.003	0.152	0.01	0.027
2000	0.002	0.001	0.001	0.01	0.01	0.014	0.01
2250	0.002	0.001	0.001	0.023	0.023	0.032	0.023
2500	0.013	0.017	0.009	0.009	0.009	0.093	0.073
2750	0.032	0.032	0.032	0.032	0.014	0.006	0.014
3000	0.048	0.036	0.036	0.036	0.036	0.044	0.041
3250	0.114	0.114	0.081	0.081	0.081	0.087	0.081
3500	0.147	0.147	0.123	0.123	0.123	0.128	0.123
3750	0.062	0.062	0.062	0.062	0.062	0.057	0.062
4000	0.128	0.128	0.128	0.128	0.131	0.138	0.131
4250	0.064	0.064	0.064	0.064	0.064	0.055	0.059
4500	0	0	0	0	0	0	0
4750	0.116	0.184	0.184	0.184	0.184	0.183	0.184
5000	0.043	0.004	0.004	0.004	0.004	0.004	0.004
5250	0	0	0.111	0.111	0.111	0.111	0.111
5500	0.272	0.272	0.272	0.282	0.282	0.282	0.282
5750	0.688	0.688	0.688	0.688	0.8	0.8	0.8
6000	0.639	0.639	0.639	0.639	0.627	0.627	0.627

Summer 1996: Coefficient of determination (r^2) values for profiler/VAD comparison

V-component

Range value (km)	20.0	22.0	24.0	26.0	28.0	30.0 (Default)	32.0
Height (m)							
500	0.286	0.286	0.286	0.286	0.286	0.243	0.286
750	0.055	0.055	0.055	0.055	0.055	0.043	0.055
1000	0.391	0.49	0.49	0.49	0.49	0.48	0.14
1250	0.552	0.751	0.516	0.516	0.506	0.507	0.52
1500	0.535	0.603	0.733	0.733	0.733	0.733	0.741
1750	0.592	0.293	0.293	0.293	0.688	0.125	0.135
2000	0.03	0.041	0.041	0.041	0.001	0	0.001
2250	0.5	0.51	0.51	0.510	0.387	0.385	0.387
2500	0.527	0.554	0.602	0.602	0.602	0.297	0.313
2750	0.497	0.497	0.497	0.497	0.518	0.492	0.518
3000	0.451	0.47	0.47	0.47	0.47	0.453	0.456
3250	0.319	0.319	0.36	0.36	0.36	0.358	0.36
3500	0.286	0.286	0.35	0.35	0.35	0.354	0.35
3750	0.404	0.404	0.408	0.408	0.408	0.399	0.408
4000	0.368	0.368	0.368	0.368	0.357	0.349	0.357
4250	0.15	0.15	0.15	0.15	0.15	0.106	0.161
4500	0.099	0.086	0.086	0.086	0.086	0.106	0.089
4750	0.121	0.091	0.091	0.091	0.091	0.083	0.091
5000	0.592	0.293	0.293	0.293	0.688	0.125	0.135
5250	0.319	0.319	0.36	0.36	0.36	0.358	0.36
5500	0.121	0.091	0.091	0.091	0.091	0.083	0.091
5750	0.592	0.293	0.293	0.293	0.688	0.125	0.135
6000	0.319	0.319	0.36	0.36	0.36	0.358	0.36

APPENDIX F

Coefficient of determination (r^2) values from modification of the VAD range adaptable parameter for the comparison between the VAD wind and the rawinsonde wind data

This appendix is a combination of section two of appendix B with appendix D. For a quick and easy comparison, the calculated coefficient of determination (r^2) values are listed for each value of the VAD range adaptable parameter used in the comparison between the VAD wind data and the rawinsonde data. There are a total of eight tables. Each season has a table for the (r^2) values of the u-component and the v-component An explanation of the table is given below.

Note: A dummy value of 2 was assigned to heights where the (r^2) value was not calculated due to zero, one, or two matches. An entire row of zeros was used if there was no match at a particular height. A single column may have a value of zero if the (r^2) value was smaller than three decimal places.

Fall 1995: Coefficient of determination (r^2) values for rawinsonde/VAD comparison

U-component

Range value (km)	20.0	22.0	24.0	26.0	28.0	30.0 (Default)	32.0
Height (m)							
600	0	0	0	0	0	0	0
900	0.9	0.9	0.9	0.9	0.9	0.887	2
1200	2	2	0.35	0.35	0.35	0.476	0.35
1500	0	0	0	0	0	0	0
1800	2	2	2	2	0	0	0
2100	2	2	2	2	2	0.024	2
2400	0.942	0.942	0.942	0.942	0.942	0.042	2
2700	2	2	2	2	2	0.064	2
3000	0	0	0	0	0	0	0
3300	2	2	2	2	2	2	2
3600	2	2	2	2	2	0.481	2
3900	2	2	2	2	2	0	2
4200	2	2	2	2	2	2	2
4500	0	0	0	0	0	0	0
4800	2	2	2	2	2	2	2
5100	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0

Fall 1995: Coefficient of determination (r^2) values for rawinsonde/VAD comparison

V -component

Range value (km)	20.0	22.0	24.0	26.0	28.0	30.0 (Default)	32.0
Height (m)							
600	0	0	0	0	0	0	0
900	0.811	0.811	0.811	0.811	0.811	0.786	2
1200	2	2	0.997	0.997	0.997	1	0.997
1500	0	0	0	0	0	0	0
1800	0	0	0	0	0	0	0
2100	2	2	2	2	2	0.974	2
2400	0.731	0.731	0.731	0.731	0.731	0.413	2
2700	2	2	2	2	2	0.323	2
3000	0	0	0	0	0	0	0
3300	2	2	2	2	2	2	2
3600	2	2	2	2	2	0.067	2
3900	0	0	0	0	0	0	0
4200	2	2	2	2	2	2	2
4500	0	0	0	0	0	0	0
4800	2	2	2	2	2	2	2
5100	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0

Winter 1996: Coefficient of determination (r^2) values for rawinsonde/VAD comparison

U-component

Range value (km)	20.0	22.0	24.0	26.0	28.0	30.0 (Default)	32.0
Height (m)							
600	0.609	0.609	0.609	0.609	0.609	0.797	0.609
900	0.917	0.917	0.917	0.917	0.917	0.969	0.957
1200	0.936	0.936	0.714	0.83	0.83	0.828	0.83
1500	0.91	0.969	0.993	0.993	0.993	1	0.993
1800	0.963	0.803	0.803	0.803	0.803	2	2
2100	0.735	0.735	0.735	0.726	0.726	0.761	0.726
2400	0.849	0.849	0.501	0.501	0.501	0.958	0.539
2700	0.849	0.849	0.849	0.849	0.521	0.398	0.521
3000	0.238	0.303	0.303	0.303	0.303	0.079	0.311
3300	2	2	2	2	2	2	2
3600	0.143	0.143	0.143	0.01	0.01	0.105	0.01
3900	0	0	0	0	0	0	0
4200	0.01	0.01	0.01	0.01	0.01	2	2
4500	0	0	0	0	0	0	0
4800	2	2	2	2	2	2	2
5100	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0
6000	2	2	2	2	2	2	2

Winter 1996: Coefficient of determination (r^2) values for rawinsonde/VAD comparison

V -component

Range value (km)	**20.0**	**22.0**	**24.0**	**26.0**	**28.0**	**30.0 (Default)**	**32.0**
Height (m)							
600	0.163	0.163	0.163	0.163	0.163	0.177	0.163
900	0.97	0.97	0.97	0.97	0.97	0.904	0.781
1200	0.986	0.986	0.639	0.742	0.742	0.79	0.742
1500	0.956	0.944	0.938	0.938	0.938	0.999	0.938
1800	0.982	0.999	0.999	0.999	0.999	2	2
2100	0.694	0.694	0.694	0.949	0.949	0.864	0.949
2400	0.445	0.445	0.426	0.426	0.426	0.962	0.275
2700	0.966	0.966	0.966	0.966	0.954	0.941	0.954
3000	0.515	0.992	0.992	0.992	0.992	0.939	0.998
3300	2	2	2	2	2	2	2
3600	0.919	0.919	0.919	0.938	0.938	0.744	0.938
3900	0	0	0	0	0	0	0
4200	0.074	0.074	0.074	0.074	0.074	2	2
4500	0	0	0	0	0	0	0
4800	2	2	2	2	2	2	2
5100	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0
6000	2	2	2	2	2	2	2

Spring 1996: Coefficient of determination (r^2) values for rawinsonde/VAD comparison

U-component

Range value (km)	20.0	22.0	24.0	26.0	28.0	30.0 (Default)	32.0
Height (m)							
600	2	2	2	2	2	2	2
900	0.157	0.157	0.157	0.157	0.157	0.157	2
1200	0	2	0.05	0.05	0.05	0.05	0.05
1500	0.051	2	2	2	2	2	0
1800	0.021	0.111	0.111	0.111	2	2	0
2100	0.018	0.018	0.018	0.028	0.028	0.028	0.028
2400	0.002	0.002	0.002	0.002	0.002	0.004	0.004
2700	0.001	0.001	0.001	0.001	0.001	0.001	0.001
3000	2	2	2	2	2	2	2
3300	0.066	0.066	0.066	0.066	0.066	0.066	0.066
3600	0.569	0.569	0.569	0.569	0.569	0.569	0.569
3900	0	0	0	0	0	0	0
4200	0.578	0.578	0.578	0.578	0.578	0.578	0.578
4500	0	0	0	0	0	0	0
4800	0.373	0.373	0.373	0.373	0.373	0.373	0.373
5100	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0
6000	2	2	2	2	2	2	2

Spring 1996: Coefficient of determination (r^2) values for rawinsonde/VAD comparison

V -component

Range value (km)	20.0	22.0	24.0	26.0	28.0	30.0 (Default)	32.0
Height (m)							
600	2	2	2	2	2	2	2
900	0.025	0.025	0.025	0.025	0.025	0.025	2
1200	0	2	0.002	0.002	0.002	0.002	0.002
1500	0.166	2	2	2	2	2	0
1800	0.166	0.241	0.241	0.241	2	2	0
2100	0.162	0.162	0.162	0.248	0.248	0.248	0.248
2400	0.183	0.183	0.183	0.183	0.183	0.003	0.003
2700	0.41	0.41	0.41	0.41	0.41	0.41	0.41
3000	2	2	2	2	2	2	2
3300	0.722	0.722	0.722	0.722	0.722	0.722	0.722
3600	0.877	0.877	0.877	0.877	0.877	0.877	0.877
3900	0	0	0	0	0	0	0
4200	0.019	0.019	0.019	0.019	0.019	0.019	0.019
4500	0	0	0	0	0	0	0
4800	0.142	0.142	0.142	0.142	0.142	0.141	0.142
5100	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0
6000	2	2	2	2	2	2	2

Summer 1996: Coefficient of determination (r^2) values for rawinsonde/VAD comparison

U-component

Range value (km)	20.0	22.0	24.0	26.0	28.0	30.0 (Default)	32.0
Height (m)							
600	0.176	0.176	0.176	0.176	0.176	0.176	0.176
900	0.363	0.34	0.34	0.34	0.34	0.34	0.894
1200	0.999	2	0.019	0.168	0.168	0.168	0.168
1500	0.201	2	2	2	2	2	2
1800	0.174	0.153	0.153	0.153	0	0	0
2100	0.055	0.031	0.031	0.196	0.196	0.196	0.196
2400	0.066	0.147	0.147	0.147	0.147	0.032	0.032
2700	0.125	0.125	0.125	0.125	0.258	0.242	0.258
3000	0.957	0.957	0.957	0.957	0.957	0.957	0.957
3300	0.031	0.031	0.028	0.028	0.028	0.028	0.028
3600	0.13	0.13	0.13	0.13	0.13	0.13	0.13
3900	0	0	0	0	0	0	0
4200	0.138	0.138	0.138	0.138	0.138	0.169	0.169
4500	0	0	0	0	0	0	0
4800	2	2	2	2	2	2	2
5100	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0
6000	2	2	2	2	1	1	1

Summer 1996: Coefficient of determination (r^2) values for rawinsonde/VAD comparison

V-component

Range value (km)	20.0	22.0	24.0	26.0	28.0	30.0 (Default)	32.0
Height (m)							
600	0.014	0.014	0.014	0.014	0.014	0.014	0.014
900	0.331	0.606	0.606	0.606	0.606	0.606	0.442
1200	1	2	0.784	0.801	0.801	0.801	0.801
1500	0.505	2	2	2	2	2	2
1800	0.744	0.672	0.672	0.672	2	2	2
2100	0.794	0.738	0.738	0.792	0.792	0.792	0.792
2400	0.01	0.083	0.083	0.083	0.083	0.059	0.059
2700	0.747	0.747	0.747	0.747	0.754	0.715	0.754
3000	1	1	1	1	1	1	1
3300	0.491	0.491	0.474	0.474	0.474	0.474	0.474
3600	0.128	0.128	0.128	0.128	0.128	0.128	0.128
3900	0	0	0	0	0	0	0
4200	0.037	0.037	0.037	0.037	0.037	0.016	0.016
4500	0	0	0	0	0	0	0
4800	2	2	2	2	2	2	2
5100	0	0	0	0	0	0	0
5400	0	0	0	0	0	0	0
5700	0	0	0	0	0	0	0
6000	2	2	2	2	0.999	0.999	0.999

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Meteorologists have encountered problems with the Velocity Azimuth Display (VAD) algorithm in the Weather Surveillance Radar - 1988 Doppler (WSR-88D) System. One of the main causes of this problem is due to inversions in the atmosphere which cause the radar beam to subrefract or superrefract, resulting in the VAD winds to be inaccurately reported at a particular height.

Using the WSR-88D Algorithm Testing and Display System (WATADS), this research compared VAD winds from Vandenberg, CA, with rawinsonde wind data and wind profiler data also from Vandenberg. The adaptable parameters of the VAD algorithm were modified to determine if the VAD winds reported by the WSR-88D could be improved.

This research discovered that only modifying the VAD range adaptable parameter resulted in any significant improvement in the VAD winds. However, no single range value improved the VAD winds at all levels of the atmosphere. Changing the value of the VAD range adaptable parameter is seasonally and station dependent.

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